2018 SchweserNotes™ Part II

FRM® Exam Prep

Credit Risk Measurement and Management

eBook 2

KAPLAN SCHWESER

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FRM Part II Book 2: Credit Risk Measurement and Management

FRM 2018 PART II BOOK 2: CREDIT RISK MEASUREMENT AND MANAGEMENT

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Reading Assignments and Learning Objectives

The following material is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by the Global Association of Risk Professionals.

Reading Assignments

Learning Objectives

16. The Credit Decision

After completing this reading, you should be able to:
1. Define credit risk and explain how it arises using examples. (page 1)
2. Explain the components of credit risk evaluation. (page 2)
3. Describe, compare and contrast various credit risk mitigants and their role in credit analysis. (page 2)
4. Compare and contrast quantitative and qualitative techniques of credit risk evaluation. (page 4)
5. Compare the credit analysis of consumers, corporations, financial institutions, and sovereigns. (page 5)
6. Describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon. (page 7)
7. Compare bank failure and bank insolvency. (page 9)

17. The Credit Analyst

After completing this reading, you should be able to:
1. Describe, compare and contrast various credit analyst roles. (page 15)
2. Describe common tasks performed by a banking credit analyst. (page 20)
3. Describe the quantitative, qualitative, and research skills a banking credit analyst is expected to have. (page 21)
4. Assess the quality of various sources of information used by a credit analyst. (page 22)

18. Classifications and Key Concepts of Credit Risk

After completing this reading, you should be able to:
1. Describe the role of ratings in credit risk management. (page 28)
2. Describe classifications of credit risk and their correlation with other financial risks. (page 28)
3. Define default risk, recovery risk, exposure risk and calculate exposure at default. (page 29)
4. Explain expected loss, unexpected loss, VaR, and concentration risk, and describe the differences among them. (page 30)
5. Evaluate the marginal contribution to portfolio unexpected loss. (page 32)
6. Define risk-adjusted pricing and determine risk-adjusted return on risk-adjusted capital (RARORAC). (page 32)

19. Rating Assignment Methodologies

After completing this reading, you should be able to:
1. Explain the key features of a good rating system. (page 38)
2. Describe the experts-based approaches, statistical-based models, and numerical approaches to predicting default. (page 39)
3. Describe a rating migration matrix and calculate the probability of default, cumulative probability of default, marginal probability of default, and annualized default rate. (page 40)
4. Describe rating agencies' assignment methodologies for issue and issuer ratings. (page 41)

5. Describe the relationship between borrower rating and probability of default. (page 42)
6. Compare agencies' ratings to internal experts-based rating systems. (page 42)
7. Distinguish between the structural approaches and the reduced-form approaches to predicting default. (page 43)
8. Apply the Merton model to calculate default probability and the distance to default and describe the limitations of using the Merton model. (page 44)
9. Describe linear discriminant analysis (LDA), define the Z-score and its usage, and apply LDA to classify a sample of firms by credit quality. (page 45)
10. Describe the application of logistic regression model to estimate default probability. (page 48)
11. Define and interpret cluster analysis and principal component analysis. (page 49)
12. Describe the use of a cash flow simulation model in assigning rating and default probability, and explain the limitations of the model. (page 52)
13. Describe the application of heuristic approaches, numeric approaches, and artificial neural network in modeling default risk and define their strengths and weaknesses. (page 53)
14. Describe the role and management of qualitative information in assessing probability of default. (page 56)

20. Credit Risks and Credit Derivatives

After completing this reading, you should be able to:

1. Using the Merton model, calculate the value of a firm's debt and equity and the volatility of firm value. (page 63)
2. Explain the relationship between credit spreads, time to maturity, and interest rates, and calculate credit spread. (page 68)
3. Explain the differences between valuing senior and subordinated debt using a contingent claim approach. (page 71)
4. Explain, from a contingent claim perspective, the impact of stochastic interest rates on the valuation of risky bonds, equity, and the risk of default. (page 71)
5. Compare and contrast different approaches to credit risk modeling, such as those related to the Merton model, CreditRisk+, CreditMetrics, and the KMV model. (page 75)
6. Assess the credit risks of derivatives. (page 80)
7. Describe a credit derivative, credit default swap, and total return swap. (page 80)
8. Explain how to account for credit risk exposure in valuing a swap. (page 83)

21. Spread Risk and Default Intensity Models

After completing this reading, you should be able to:

1. Compare the different ways of representing credit spreads. (page 90)
2. Compute one credit spread given others when possible. (page 90)
3. Define and compute the Spread '01. (page 91)
4. Explain how default risk for a single company can be modeled as a Bernoulli trial. (page 92)
5. Explain the relationship between exponential and Poisson distributions. (page 93)
6. Define the hazard rate and use it to define probability functions for default time and conditional default probabilities. (page 93)
7. Calculate the conditional default probability given the hazard rate. (page 93)
8. Calculate risk-neutral default rates from spreads. (page 95)
9. Describe advantages of using the CDS market to estimate hazard rates. (page 96)

10. Explain how a CDS spread can be used to derive a hazard rate curve. (page 97)
11. Explain how the default distribution is affected by the sloping of the spread curve. (page 99)
12. Define spread risk and its measurement using the mark-to-market and spread volatility. (page 100)

22. Portfolio Credit Risk

After completing this reading, you should be able to:

1. Define and calculate default correlation for credit portfolios. (page 107)
2. Identify drawbacks in using the correlation-based credit portfolio framework. (page 108)
3. Assess the impact of correlation on a credit portfolio and its Credit VaR. (page 109)
4. Describe the use of a single factor model to measure portfolio credit risk, including the impact of correlation. (page 111)
5. Define and calculate Credit VaR. (page 109)
6. Describe how Credit VaR can be calculated using a simulation of joint defaults. (page 116)

23. Structured Credit Risk

After completing this reading, you should be able to:

1. Describe common types of structured products. (page 122)
2. Describe tranching and the distribution of credit losses in a securitization. (page 123)
3. Describe a waterfall structure in a securitization. (page 124)
4. Identify the key participants in the securitization process, and describe conflicts of interest that can arise in the process. (page 127)
5. Compute and evaluate one or two iterations of interim cashflows in a three-tiered securitization structure. (page 128)
6. Describe a simulation approach to calculating credit losses for different tranches in a securitization. (page 131)
7. Explain how the default probabilities and default correlations affect the credit risk in a securitization. (page 132)
8. Explain how default sensitivities for tranches are measured. (page 134)
9. Describe risk factors that impact structured products. (page 134)
10. Define implied correlation and describe how it can be measured. (page 135)
11. Identify the motivations for using structured credit products. (page 135)

24. Counterparty Risk

After completing this reading, you should be able to:

1. Describe counterparty risk and differentiate it from lending risk. (page 143)
2. Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction. (page 144)
3. Identify and describe institutions that take on significant counterparty risk. (page 145)
4. Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default, and the recovery rate. (page 146)
5. Identify and describe the different ways institutions can quantify, manage and mitigate counterparty risk. (page 147)

25. Netting, Close-out and Related Aspects

After completing this reading, you should be able to:
1. Explain the purpose of an ISDA master agreement. (page 153)
2. Summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement. (page 153)
3. Describe the effectiveness of netting in reducing credit exposure under various scenarios. (page 156)
4. Describe the mechanics of termination provisions and trade compressions and explain their advantages and disadvantages. (page 156)
5. Identify and describe termination events and discuss their potential effects on parties to a transaction. (page 156)

26. Collateral

After completing this reading, you should be able to:
1. Describe the rationale for collateral management. (page 161)
2. Describe the terms of a collateral and features of a credit support annex (CSA) within the ISDA Master Agreement including threshold, initial margin, minimum transfer amount and rounding, haircuts, credit quality, and credit support amount. (page 161)
3. Describe the role of a valuation agent. (page 162)
4. Describe the mechanics of collateral and the types of collateral that are typically used. (page 163)
5. Explain the process for the reconciliation of collateral disputes. (page 163)
6. Explain the features of a collateralization agreement. (page 164)
7. Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality. (page 166)
8. Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization. (page 166)

27. Credit Exposure and Funding

After completing this reading, you should be able to:
1. Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective exposure, and maximum exposure. (page 173)
2. Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure. (page 176)
3. Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure. (page 176)
4. Identify typical credit exposure profiles for various derivative contracts and combination profiles. (page 177)
5. Explain how payment frequencies and exercise dates affect the exposure profile of various securities. (page 180)
6. Explain the impact of netting on exposure, the benefit of correlation, and calculate the netting factor. (page 181)
7. Explain the impact of collateralization on exposure, and assess the risk associated with the remargining period, threshold, and minimum transfer amount. (page 182)

28. Counterparty Risk Intermediation

After completing this reading, you should be able to:

1. Identify counterparty risk intermediaries including central counterparties (CCPs), derivative product companies (DPCs), special purpose vehicles (SPVs), and monoline insurance companies (monolines) and describe their roles. (page 193)
2. Describe the risk management process of a CCP and explain the loss waterfall structure of a CCP. (page 196)
3. Compare bilateral and centrally cleared over-the-counter (OTC) derivative markets. (page 198)
4. Assess the capital requirements for a qualifying CCP and discuss the advantages and disadvantages of CCPs. (page 199)
5. Discuss the impact of central clearing on credit value adjustment (CVA), funding value adjustment (FVA), capital value adjustment (KVA), and margin value adjustment (MVA). (page 200)

29. Default Probabilities, Credit Spreads and Funding Costs

After completing this reading, you should be able to:

1. Distinguish between cumulative and marginal default probabilities. (page 205)
2. Calculate risk-neutral default probabilities, and compare the use of risk-neutral and real-world default probabilities in pricing derivative contracts. (page 206)
3. Compare the various approaches for estimating price: historical data approach, equity based approach, and risk neutral approach. (page 207)
4. Describe how recovery rates may be estimated. (page 209)
5. Describe credit default swaps (CDS) and their general underlying mechanics. (page 210)
6. Describe the credit spread curve and explain the motivation for curve mapping. (page 211)
7. Describe types of portfolio credit derivatives. (page 211)
8. Describe index tranches, super senior risk, and collateralized debt obligations (CDOs). (page 212)

30. Credit and Debt Value Adjustments

After completing this reading, you should be able to:

1. Explain the motivation for and the challenges of pricing counterparty risk. (page 219)
2. Describe credit value adjustment (CVA). (page 219)
3. Calculate CVA and the CVA spread with no wrong-way risk, netting, or collateralization. (page 219)
4. Evaluate the impact of changes in the credit spread and recovery rate assumptions on CVA. (page 221)
5. Explain how netting can be incorporated into the CVA calculation. (page 222)
6. Define and calculate incremental CVA and marginal CVA, and explain how to convert CVA into a running spread. (page 222)
7. Explain the impact of incorporating collateralization into the CVA calculation. (page 222)
8. Describe debt value adjustment (DVA) and bilateral CVA (BCVA). (page 223)
9. Calculate BCVA and BCVA spread. (page 223)

31. Wrong-way Risk

After completing this reading, you should be able to:
1. Describe wrong-way risk and contrast it with right-way risk. (page 231)
2. Identify examples of wrong-way risk and examples of right-way risk. (page 232)
3. Discuss the impact of wrong-way risk on collateral and central counterparties. (page 237)

32. The Evolution of Stress Testing Counterparty Exposures

After completing this reading, you should be able to:
1. Differentiate among current exposure, peak exposure, expected exposure, and expected positive exposure. (page 242)
2. Explain the treatment of counterparty credit risk (CCR) both as a credit risk and as a market risk and describe its implications for trading activities and risk management for a financial institution. (page 243)
3. Describe a stress test that can be performed on a loan portfolio and on a derivative portfolio. (page 244)
4. Calculate the stressed expected loss, the stress loss for the loan portfolio and the stress loss on a derivative portfolio. (page 245)
5. Describe a stress test that can be performed on CVA. (page 246)
6. Calculate the stressed CVA and the stress loss on CVA. (page 246)
7. Calculate the DVA and explain how stressing DVA enters into aggregating stress tests of CCR. (page 248)
8. Describe the common pitfalls in stress testing CCR. (page 249)

33. Credit Scoring and Retail Credit Risk Management

After completing this reading, you should be able to:
1. Analyze the credit risks and other risks generated by retail banking. (page 254)
2. Explain the differences between retail credit risk and corporate credit risk. (page 255)
3. Discuss the "dark side" of retail credit risk and the measures that attempt to address the problem. (page 255)
4. Define and describe credit risk scoring model types, key variables, and applications. (page 256)
5. Discuss the key variables in a mortgage credit assessment and describe the use of cutoff scores, default rates, and loss rates in a credit scoring model. (page 257)
6. Discuss the measurement and monitoring of a scorecard performance including the use of cumulative accuracy profile (CAP) and the accuracy ratio (AR) techniques. (page 258)
7. Describe the customer relationship cycle and discuss the trade-off between creditworthiness and profitability. (page 259)
8. Discuss the benefits of risk-based pricing of financial services. (page 260)

34. The Credit Transfer Markets—and Their Implications

After completing this reading, you should be able to:
1. Discuss the flaws in the securitization of subprime mortgages prior to the financial crisis of 2007. (page 265)
2. Identify and explain the different techniques used to mitigate credit risk, and describe how some of these techniques are changing the bank credit function. (page 267)

3. Describe the originate-to-distribute model of credit risk transfer and discuss the two ways of managing a bank credit portfolio. (page 268)
4. Describe the different types and structures of credit derivatives including credit default swaps (CDS), first-to-default put, total return swaps (TRS), asset-backed credit-linked note (CLN), and their applications. (page 269)
5. Explain the credit risk securitization process and describe the structure of typical collateralized loan obligations (CLOs) or collateralized debt obligations (CDOs). (page 273)
6. Describe synthetic CDOs and single-tranche CDOs. (page 275)
7. Assess the rating of CDOs by rating agencies prior to the 2007 financial crisis. (page 275)

35. An Introduction to Securitization

After completing this reading, you should be able to:

1. Define securitization, describe the securitization process and explain the role of participants in the process. (page 281)
2. Explain the terms over-collateralization, first-loss piece, equity piece, and cash waterfall within the securitization process. (page 283)
3. Analyze the differences in the mechanics of issuing securitized products using a trust versus a special purpose vehicle (SPV) and distinguish between the three main SPV structures: amortizing, revolving, and master trust. (page 284)
4. Explain the reasons for and the benefits of undertaking securitization. (page 286)
5. Describe and assess the various types of credit enhancements. (page 287)
6. Explain the various performance analysis tools for securitized structures and identify the asset classes they are most applicable to. (page 288)
7. Define and calculate the delinquency ratio, default ratio, monthly payment rate (MPR), debt service coverage ratio (DSCR), the weighted average coupon (WAC), the weighted average maturity (WAM), and the weighted average life (WAL) for relevant securitized structures. (page 290)
8. Explain the prepayment forecasting methodologies and calculate the constant prepayment rate (CPR) and the Public Securities Association (PSA) rate. (page 293)
9. Explain the decline in demand in the new-issue securitized finance products following the 2007 financial crisis. (page 295)

36. Understanding the Securitization of Subprime Mortgage Credit

After completing this reading, you should be able to:

1. Explain the subprime mortgage credit securitization process in the United States. (page 301)
2. Identify and describe key frictions in subprime mortgage securitization, and assess the relative contribution of each factor to the subprime mortgage problems. (page 301)
3. Describe the characteristics of the subprime mortgage market, including the creditworthiness of the typical borrower and the features and performance of a subprime loan. (page 304)
4. Describe the credit ratings process with respect to subprime mortgage backed securities. (page 305)
5. Explain the implications of credit ratings on the emergence of subprime related mortgage backed securities. (page 305)
6. Describe the relationship between the credit ratings cycle and the housing cycle. (page 305)

7. Explain the implications of the subprime mortgage meltdown on portfolio management. (page 306)
8. Compare predatory lending and borrowing. (page 306)

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

The Credit Decision

Topic 16

Exam Focus

This topic provides an overview of the credit analysis process. Credit risk can arise from multiple sources, including default, an increased probability of default, failure to perform on a prepaid obligation, more severe losses than forecasted resulting from greater exposure than expected, or smaller recoveries than expected given a default. For the exam, be able to compare and contrast the credit analysis process for consumers (i.e., individuals), nonfinancial firms, financial firms, and to a lesser degree sovereigns. Also, be able to distinguish between the probability of default (PD), the loss given default (LGD), the exposure at default (EAD), and the overall expected loss (EL). Understand that it is simple to measure these factors after the fact but difficult to forecast losses in advance. Finally, understand that outside of times of stress or crisis, banks rarely fail. Credit analysts must determine where a financial institution falls on a continuum between perfectly creditworthy and bankrupt.

Credit Risk

LO 16.1: Define credit risk and explain how it arises using examples.

Credit is an agreement where one party receives something of value and agrees to pay for the good or service at a later date. The word "credit" is derived from the ancient Latin word *credere,* which means "to believe" or "to entrust." The creditor must have knowledge of the borrower's character and reputation as well as his financial condition. Generally, there is not a definitive yes or no answer to whether a borrower can and will pay back a loan. As such, the lender must address the question of likelihood. The lender must assess the likelihood that the borrower will pay back the loan in accordance with the terms of the agreement.

Professor's Note: Borrower, obligor, counterparty, and issuer are all used to signify the party receiving credit. Lender, creditor, and obligee are primarily used to signify the party granting credit.

Credit risk is the probability that a borrower will not pay back a loan in accordance with the terms of the credit agreement. The risk can result from:

- Default on a financial obligation.
- An increased probability of default on a financial obligation.
- A more severe loss than expected due to a greater than expected exposure at the time of a default.
- A more severe loss than expected due to a lower than expected recovery at the time of a default.
- Default on payment for goods or services already rendered (i.e., settlement risk).

Credit risk arises in many personal and business contexts. In fact, nearly all businesses, except small firms that confine their businesses to "cash and carry" transactions (i.e., a good or service is exchanged simultaneously for cash), incur credit risk. Specific contexts in which credit risks arise include:

- A person or company performs a service and sends a bill for payment of the rendered service. For example, a car dealership fixes a person's car and then bills the customer, giving the customer 30 days to pay the bill in full without incurring financing charges.
- A party pays in advance for goods or services and awaits receipt of the goods or services (i.e., the settlement of a transaction). For example, a university pays in advance for computer training for its staff and faculty and then receives the training over the course of the following year.
- A person or company has provided a product and is awaiting payment for the item. **Trade credit** is an example of this type of transaction. The firm selling the product offers "terms of credit," allowing the purchaser a reasonable period of time to pay the invoice. Big-ticket items are almost exclusively sold on credit. For example, a chemistry firm buys several powerful microscopes from a supplier and is allowed to pay the full balance in 30 days.

There are two types of risks associated with these transactions. There is **settlement risk**, the risk that the counterparty will never pay for the good or service, and a more fundamental **financial obligation** that arises from the loan agreement. Credit risk that arises from trade credit is nearly indistinguishable from the credit risk that banks incur. Financial analysis must be performed in both cases to increase the likelihood that the borrower will fulfill the financial obligation. Banks cannot avoid credit risk; it is central to their business. There is no "cash and carry" model in banking. Banks accept money from depositors and other sources and lend the money to individuals and firms. Because banks cannot avoid credit risk, they must manage the risk through credit analysis and the use of risk mitigants such as collateral and loan guarantees.

Credit Risk Evaluation Components

LO 16.2: Explain the components of credit risk evaluation.

LO 16.3: Describe, compare and contrast various credit risk mitigants and their role in credit analysis.

The four primary components of credit risk evaluation are as follows.

1. **The borrower's (or obligor's) capacity and willingness to repay the loan.** Questions the lender must consider include:
   - What is the financial capacity to pay?
   - Is it likely the borrower can fulfill its financial obligations through the maturity of the loan?
   - Are there outside forces that affect the borrower's capacity and/or willingness to pay? For example, does the ownership structure of the firm, relationships within and outside the firm, and other obligations of the firm affect the borrower's ability to pay?
   - How does the business itself affect the borrower's capacity to pay? Are there credit risk characteristics tied to this particular industry or sector? Does the firm have a niche within the industry or sector?

2. **The external environment and its effect on the borrower's capacity and willingness to repay the borrowed funds.** Factors such as the business climate, country risk, and operating conditions are relevant to the lender. Are there cyclical changes that will affect the level of credit risk? Will political risks affect the likelihood of repayment?

3. **The characteristics of the credit instrument.** The credit instrument might be a bond issue, a bank loan, a loan from a finance company, trade credit, or other type of debt agreement/security. Concerns include:
   - Risk characteristics that are inherent in the credit instrument, including legal risks and obligations that are specific to the instrument.
   - The maturity (also called "tenor") of the instrument.
   - Is the debt secured or unsecured? Is there collateral backing the loan? Are there loan guarantors?
   - Is the debt subordinated or senior to other obligations? What is the priority assigned to the creditor?
   - How do loan/bond covenants increase or decrease the credit risk for each party? Can the borrower repay the loan early without penalty? Can the lender call the loan? Can the security be converted to another form (e.g., a convertible bond)?
   - What is the denominated currency of the obligation?
   - Are there any contingent risks?

4. **The quality and adequacy of risk mitigants such as collateral, credit enhancements, and loan guarantees.** Secured lending (i.e., using risk mitigants in the lending process) is generally the preferred method of lending. If there is collateral, a bank or other lender may not have to force a delinquent borrower into bankruptcy but may instead sell the collateral to satisfy the financial obligation. Secured lenders are also generally in a better position than unsecured lenders in the event of bankruptcy. The use of collateral not only mitigates losses in the event of default, but also lowers the probability of default because the obligor typically does not want to lose the collateral. Historically, banks have substituted collateral for analysis of the borrower's ability to pay. In some sense, the use of collateral eliminates the need for credit analysis, or at the very least makes the credit decision simpler. A lender can normally put a market value on collateral and determine if it is sufficient to cover potential losses. Three issues regarding risk mitigants include:
   - Is the collateral pledged to, or likely to be pledged to, another loan?
   - Has there been an estimation of the value of the collateral?
   - If there is a loan guarantor, has there been sufficient credit analysis of the third party's willingness and ability to pay in the event the borrower does not pay? A guarantor accepts liability for debt if the primary borrower defaults. The bank is able to substitute analysis of the guarantor's creditworthiness for that of the primary borrower. Typically, the guarantor has a greater ability to pay than the primary borrower (e.g., a parent guaranteeing a child's car loan or a parent company guaranteeing a loan to a subsidiary).

Qualitative and Quantitative Techniques

LO 16.4: Compare and contrast quantitative and qualitative techniques of credit risk evaluation.

The willingness to repay a loan is a subjective attribute. Lenders must make unverifiable judgments about the borrower. In some cases, intuition, or "gut feelings," are necessary to conclude whether a borrower is willing to repay a loan. As such, **qualitative credit analysis techniques** are largely used to evaluate the borrower's willingness to repay. Qualitative techniques include:

- **Gather information** from a variety of sources about the character and reputation of the potential borrower. Old-fashioned lending relied on first-hand knowledge of the people and businesses in a town. In this case, lenders knew (or thought they knew) potential borrowers. It is more difficult in the modern world, where lending decisions are centralized, to know customers personally.
- **Face-to-face meetings** with the potential borrower to assess the borrower's character are routine in evaluating willingness to pay.
- "**Name lending**" involves lending to an individual based on the perceived status of the individual in the business community. Some lenders substitute name lending for financial analysis.
- **Extrapolating past performance into the future.** Lenders often assume that a pattern of borrowing and repaying in the past (e.g., a credit record compiled from past history with the borrower and data garnered from credit bureaus) will continue in the future.

Historical lending norms relied on the *moral obligation* of borrowers who could pay to repay their debts. Thus, gauging the borrower's willingness to pay was a critical component of credit analysis. However, in modern society, the moral obligation to pay if one is capable of paying has been replaced by the legal obligation to pay. In other words, in terms of credit analysis, determining the capacity to pay is more important than determining the willingness to pay because the legal system will force those who can pay to honor their commitment. Courts can seize the assets of those who will not fulfill their financial obligations. In corrupt or ineffective states, a borrower will not suffer, even if able to pay but not doing so.

The willingness to pay is more important in countries with less-developed financial markets and legal systems. Creditors must evaluate the legal system and the strength of creditors' rights in emerging markets, along with the prospective borrower's ability and willingness to repay the obligation. This is a qualitative endeavor. **Sovereign risk ratings** may be used to evaluate the quality of a country's legal system and, by extension, the legal risk associated with the country or region. The lower the score, the greater the legal risk. For example, in 2010, Finland had a Rule of Law Index of 1.97, the United States had a rating of 1.58, Brazil had a rating of 0.0, and Somalia had a rating of –2.43. However, even in countries with robust legal systems such as Finland and the United States, the creditor must also consider the costs associated with taking legal action against a delinquent borrower. If costs are high, the creditor may be unwilling to take action regardless of the strength of the enforcement of creditor rights. As such, the willingness to pay should never be completely ignored in credit analysis.

The ability of a borrower to repay a loan is an objective attribute. **Quantitative credit analysis techniques** are largely used to evaluate the borrower's ability to repay. The primary quantitative technique used in financial analysis is examining the past, current, and forecasted financial statements of the prospective borrower. This forms the core of the quantitative credit analysis used to determine a borrower's capacity to meet its financial obligations. There are limitations associated with quantitative data, which include:

- **Historical nature of the data.** Financial data is typically historical and thus may not be up-to-date or representative of the future. Also, forecasted financial data is notoriously unreliable and susceptible to miscalculations and/or misrepresentations.
- **Difficult to make accurate projections using historical data.** Financial statements attempt to represent the economic reality of a firm in a highly abbreviated report. As such, some information is lost in translation that is critical to the loan decision. The rules guiding financial reporting are created by a diverse group with varying interests and are often decided by compromise. Also, firms are given discretion regarding what and how they report financial information, subject to established accounting rules. Firms may use the latitude in financial reporting to deceive interested parties. Even if the reports are accurate, financial data is subject to interpretation. There can be a range of conclusions drawn from the same data due to the variety of needs, perspectives, and experiences of the various analysts. This means there is a subjective, qualitative component to an objective, quantitative exercise.

Given the shortcomings of financial reporting, lenders should not ignore qualitative analysis. The quality of management, the motivation of the firm's management, and the incentives of management are relevant for both nonfinancial and financial firms. Even quantitative analysis is subject to interpretation. In fact, many would argue that financial analysis is much more of an art than a science. Judgment is as important as the quantitative analysis supporting it. The most effective analysis combines quantitative assessments with qualitative judgments.

Credit Analysis Comparison

LO 16.5: Compare the credit analysis of consumers, corporations, financial institutions, and sovereigns.

Four basic types of borrowers for which credit analysis must be performed are as follows:

1. **Consumers**—the analyst evaluates the creditworthiness of individuals.

2. **Corporations**—the analyst evaluates the creditworthiness of nonfinancial firms. Businesses are typically more difficult to analyze than individuals, although the process is similar.

3. **Financial institutions**—the analyst evaluates the creditworthiness of financial institutions, including banks and nonbank firms such as insurance companies and investment companies.

4. **Government or government-related entities (i.e., sovereigns)**—the analyst evaluates the creditworthiness of nations, government bodies, and municipalities. Non-state entities in specific locations or jurisdictions are also subject to analysis in the sovereign category.

There are similarities and differences in the approaches taken to analyze the creditworthiness of the various groups. Figure 1 details some specific aspects of each type of analysis.

Figure 1: Comparison of Borrowers

	Consumers	*Corporations*	*Financial Institutions*	*Sovereigns*
Capacity	Wealth (i.e., net worth), salary, or incoming cash per period, expenses per period, assets such as houses and cars, amount of debt (e.g., credit card debt), net cash available to service debt (i.e., cash flow minus household and mortgage expenses).	Liquidity, cash flow combined with earnings capacity and profitability, capital position (solvency), state of the economy, strength of the industry.	Similar to nonfinancial firms but bank specific. Liquidity (the bank's access to cash to meet obligations), capital position, historical performance including earnings capacity over time (and ability to withstand financial stress), asset quality (affects the bank's likelihood of being paid back and by extension the bank's lender's likelihood of being paid back), state of the economy, strength of the industry.	Financial factors including the country's external debt load and debt relative to the overall economy; tax receipts are important.
Willingness	Reputation of individual, payment history.	Quality of management, historical debt service.	Quality of management; qualitative analysis is even more important for financial firms than for nonfinancial firms.	Credit analysis for sovereigns is often more subjective than for financial and nonfinancial firms because the legal system and the enforcement of creditor rights is critical to the analysis. Sovereign legal risk ratings, as discussed previously, are often considered in the analysis.

Figure 1: Comparison of Borrowers (Cont.)

	Consumers	*Corporations*	*Financial Institutions*	*Sovereigns*
Methods of evaluation	Credit scoring models that consider income, duration of employment, and amount of debt for unsecured debt like credit cards. Credit scoring and some manual input and review for large exposures such as mortgage loans or automobile loans.	Detailed manual analysis including financial statement analysis, interviews with management. More complex than consumer analysis because companies are so diverse in terms of assets, cash flow, financial structure, etc.	Similar to nonfinancial firms.	Similar to financial and nonfinancial firms but with increased subjective analysis of the political environment.
Loan size/type	Large exposures are typically secured (e.g., mortgage loans). Smaller exposures are unsecured (e.g., credit card loans).	Typically larger exposures (sometimes considerably larger) than loans to consumers. Debt may be secured or unsecured.	Similar to nonfinancial firms (i.e., large).	Similar to nonfinancial and financial firms (i.e., large).

The two primary differences between nonfinancial firm credit analysis and financial firm credit analysis are (1) the importance of the quality of assets in financial firms and (2) cash flow as an indicator of capacity to repay for nonfinancial firms but not a key indicator of creditworthiness for financial firms. It is clear from the 2007–2009 financial crisis that asset quality is a key indicator of a bank's financial health. The ability to withstand financial stress is critical for a bank. That is why earnings capacity over time is a more relevant indicator of creditworthiness than cash flow. A bank must be able to withstand periods of financial stress/crisis in order to repay debts.

Professor's Note: Sovereign credit analysis is not explicitly discussed in this topic. However, in contrast to consumers and financial and nonfinancial firms, consider the political issues/concerns that would arise when lending to a foreign government. Even a financially healthy sovereign may be a risky loan candidate due to the legal system's strength (or lack thereof); a lack of legal protections for creditors and other factors might negatively affect the lender and the lender's rights. If you have to compare credit analysis across the four groups (i.e., consumers, nonfinancial firms, financial firms, and sovereigns), think about the differences between the groups and the various factors that explain and/or increase/decrease the lender's risk in each case.

Quantitative Measures

LO 16.6: Describe quantitative measurements and factors of credit risk, including probability of default, loss given default, exposure at default, expected loss, and time horizon.

Credit risk, the likelihood that a borrower will repay a loan according to the loan agreement, and default risk, the probability that a borrower will default, are essentially the

same because a default on a financial obligation almost always results in a loss to the lender. In the last decade, there have been significant changes in the financial sector. These changes, combined with regulatory changes in the industry, have resulted in a somewhat revised view of credit and default risks. Current measures used to evaluate creditworthiness are described as follows:

Probability of default (PD): The likelihood that a borrower will default is not necessarily the creditor's greatest concern. A borrower may briefly default and then quickly correct the situation by making a payment, paying interest charges or penalties for missed payments. Creditors must rely on other measures of risk in addition to PD.

Loss given default (LGD): LGD represents the likely percentage loss if the borrower defaults. The severity of a default is equally as important to the creditor as the likelihood that the default would occur in the first place. If the default is brief and the creditor suffers no loss as a result, it is less of a concern than if the default is permanent and the creditor suffers significant losses. Both PD and LGD are expressed as percentages.

Exposure at default (EAD): The loss exposure may be stated as a dollar amount (e.g., the loan balance outstanding). EAD can also be stated as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.

Expected loss (EL): Expected loss for a given time horizon is calculated as the product of the PD, LGD, and EAD (i.e., PD × LGD × EAD).

Time horizon: The longer the time horizon (i.e., the longer the tenor of the loan), the greater the risk to the lender and the higher the probability of default. Also, EAD and LGD change with time. The exposure (EAD) increases as the borrower draws on a credit line and falls as the loan is paid down. The LGD can also change as the terms of the loan or credit line change.

Expected loss generally depends on four variables: PD, LGD, EAD, and time horizon. A bank should also consider the correlations between various risk exposures when analyzing credit risk in a portfolio context.

Example: Calculating expected loss

Star City Bank and Trust has examined its loan portfolio over the past year. It has determined that the probability of default was 4%, adjusted for the size of the exposure. The loss given default over the period was 80%. Bank risk managers estimate that the exposure at default was 75% of the potential exposure. **Calculate** the expected loss given a one-year time horizon.

Answer:

$$\text{expected loss} = 4\% \times 80\% \times 75\% = 2.4\%$$

Professor's Note: It is straightforward to calculate PD, LGD, and EAD after the fact. As the previous example illustrates, a lender can analyze historical occurrences of default, loss given default, and loss exposure. However, it is difficult to estimate these measures in advance. A financial institution or other nonbank lender can use historical experience to help predict future losses, but the forecast will not be perfect. Using historical mortgage loss data would have been little help in forecasting actual losses that occurred during the 2007–2009 financial crisis.

Failure vs. Insolvency

LO 16.7: Compare bank failure and bank insolvency.

Bank insolvency and bank failures are not identical. Banks become insolvent and are often merged into healthier institutions. It is more convenient and less expensive for the government to simply fold a troubled bank into a stronger bank than it is to close the bank. In fact, there is an assumption that bank failures are relatively common, but in reality, it rarely happens in non-crisis periods. Weak banks are merged with healthier banks, and the system avoids outright failures. This is especially true for large, international banks (i.e., banks that are "too big to fail"). In the United States, only 50 banks failed between 2001 and 2008, half of which failed in 2008. This equates to a rate of approximately 0.1% per year during the period. Following the financial crisis, approximately 2% of banks failed in both 2009 and 2010. An additional 1.2% of banks failed in 2011. Research indicates that bank failures are considerably less likely than nonfinancial firm failures.

In the last few years, beginning with the financial crisis in late 2007, many more large banks in Europe and the United States have suffered from financial stresses. However, it was clear during the crisis that some banks were considered too big to fail. In response, the Financial Stability Board (FSB) created a list of 29 "systemically important financial institutions" that are required to hold "additional loss absorption capacity tailored to the impact of their [possible] default." The concern is systemic risk that spreads to other institutions. There was substantial evidence of this occurrence during the financial crisis.

A bank can remain insolvent (without failing), so long as it has a source of liquidity. The Federal Reserve is one such source and acts as a "lender of last resort." A bank failure that results in significant losses to depositors and other creditors is quite rare, although as noted, the incidence increases in times of crisis, such as in 2007. For a credit analyst evaluating a financial institution, the expectation of an outright failure is unlikely. However, because banks are heavily leveraged, the risks cannot be ignored. The analyst must place the bank somewhere on the continuum between "pure creditworthiness" and bankrupt. At one end of the continuum are banks with AAA-rated debt, and at the other end are banks with default ratings. Thus, thinking about bank risk on a continuum is useful in defining the bank's credit risk.

Key Concepts

LO 16.1

Credit risk is the probability that a borrower will not pay back a loan in accordance with the terms of the credit agreement. Credit risk results when an individual or firm defaults on a financial obligation. It arises short of default when there is an increased probability of default on a financial obligation. A more severe loss than expected due to a greater than expected exposure at the time of a default or a more severe loss than expected due to a lower than expected recovery at the time of a default are also components of credit risk. Finally, credit risk can arise from a default on a payment for goods or services that are already rendered (i.e., settlement risk).

LO 16.2

There are four primary components of credit risk evaluation: (1) the borrower's (obligor's) willingness and capacity to repay the loan, (2) the effect of external conditions on the borrower's ability to repay the loan, (3) the inherent characteristics of the credit instrument and the extent to which the characteristics affect the borrower's willingness and ability to perform the obligation, and (4) the quality and adequacy of risk mitigants such as collateral and loan guarantees.

LO 16.3

If collateral is used as a credit risk mitigant, a bank or other lender may not have to force a delinquent borrower into bankruptcy but may instead sell the collateral to satisfy the financial obligation. If a loan guarantor is used as a credit risk mitigant, the guarantor accepts liability for debt if the primary borrower defaults. Typically, the guarantor has a greater ability to pay than the primary borrower.

LO 16.4

Qualitative techniques are used primarily to assess the borrower's willingness to repay the loan. Quantitative techniques are used primarily to assess the borrower's ability to repay the loan. Gathering information from a variety of sources about the character and reputation of the potential borrower, face-to-face interviews with potential borrowers, and using past loan payment information to draw conclusions about a borrower's willingness to pay in the future are all qualitative techniques. Analyzing the borrower's recent and past financial statements is the primary quantitative method used in credit analysis.

LO 16.5

There are key differences between the analysis of the creditworthiness of consumers, versus that of nonfinancial and financial firms. Individual factors such as a person's net worth, salary, assets, reputation, and credit score are used to evaluate individuals. It is more complex to evaluate firms. Liquidity, cash flow combined with earnings capacity and profitability, capital position (solvency), state of the economy, and strength of the industry are used to evaluate nonfinancial firms. Similar data is used for financial firms in addition to bank-specific measures such as capital adequacy, asset quality, and the bank's ability to withstand financial stress. Detailed manual analyses, including financial statement analysis and interviews with management, are used to analyze the creditworthiness of both nonfinancial and financial firms.

LO 16.6

Current measures used to evaluate credit risk are:

- The probability of default (PD), which is the likelihood that a borrower will default.
- The loss given default (LGD), which represents the likely percentage loss if the borrower does default.
- Exposure at default (EAD), which can be stated as a dollar amount (e.g., the loan balance outstanding) or as a percentage of the nominal amount of the loan or the maximum amount available on a credit line.
- Expected loss (EL), which is, for a given time horizon, calculated as the product of the PD, LGD, and EAD (i.e., PD × LGD × EAD).
- Time horizon or tenor of the loan. The longer the time horizon, the greater the risk to the lender.

LO 16.7

Bank insolvency and bank failure are not one in the same. A bank may be insolvent but avoid failure so long as liquidity is available. Also, many insolvent banks are merged with financially sound banks, avoiding outright failure. For the credit analyst, the fact that failure of financial institutions is rare makes analysis easier. However, banks are highly leveraged, placing the bank somewhere on the continuum between fully creditworthy and insolvent.

Concept Checkers

1. Blackstone Credit, Inc., made a loan to a small start-up firm. The firm grew rapidly, and it appeared that Blackstone had made a good credit decision. However, the firm grew too fast and could not sustain the growth. It eventually failed. Blackstone had initially estimated its exposure at default to be $1,200,000. Because of the firm's rapid growth and resulting increases in the line of credit, Blackstone ultimately lost $1,550,000. In terms of credit risk, this is an example of:
   A. default on payment for goods or services already rendered.
   B. a more severe loss than expected due to a ratings downgrade by a rating agency.
   C. a more severe loss than expected due to a greater than expected exposure at the time of a default.
   D. a more severe loss than expected due to a lower than expected recovery at the time of a default.

2. Brent Gulick, a credit analyst with Home Town Bank, is considering the loan application of a small, local car dealership. The dealership has been solely owned by Bob Justice for more than 20 years and sells three brands of American automobiles. Because of the rural location, most of the cars sold in the past by the dealership have been large pick-up trucks and sports utility vehicles. However, sales have declined, and gasoline prices have continued to increase. As a result, Justice is considering selling a line of hybrid cars. Justice has borrowed from Home Town Bank before but currently does not have a balance outstanding with the bank. Which of the following statements is not one of the four components of credit analysis Gulick should be evaluating when performing the credit analysis for this potential loan?
   A. The business environment, competition, and economic climate in the region.
   B. Justice's character and past payment history with the bank.
   C. The car dealership's balance sheets and income statements for the last few years as well as Justice's personal financial situation.
   D. The financial health of Justice's friends and family who could be called upon to guarantee the loan.

3. Sarah Garrison is a newly hired loan officer at Lexington Bank and Trust. Her boss told her she needs to make five commercial loans this month to meet her sales goal. Garrison talks to friends and hears about a local businessperson with a great reputation. Everyone in town says John Johnson is someone you want to meet. Garrison sets up a meeting with Johnson and is immediately impressed with his business sense. They discuss a loan for a new venture Johnson is considering, and Garrison agrees that it is a great idea. She takes the loan application back to the bank and convinces the chair of the loan committee that Lexington Bank and Trust is lucky to be able to do business with someone with Johnson's reputation. This is an example of:
   A. historical analysis technique.
   B. qualitative analysis technique.
   C. quantitative analysis technique.
   D. extrapolation analysis technique.

4. Stacy Smith is trying to forecast the potential loss on a loan her firm made to a mid-size corporate borrower. She determines that there will be a 75% loss if the borrower does not perform the financial obligation. This is the:
   A. probability of default.
   B. loss given default.
   C. expected loss.
   D. exposure at default.

5. Bank of the Plain States has been struggling with poor asset quality for some time. The bank lends primarily to large farming operations that have struggled in recent years due to a glut of soybeans and corn on the market. Bank regulators have recently required that the bank write off some of these loans, which has entirely wiped out the capital of the bank. However, the bank still has some liquidity sources it can use, including a correspondent bank and the Federal Reserve. Bank of the Plain States is:
   A. an insolvent but not failed bank.
   B. both a failed bank and an insolvent bank.
   C. neither a failed bank nor an insolvent bank.
   D. a failed bank but not an insolvent bank.

Concept Checker Answers

1. **C** Blackstone lost more than expected due to greater exposure at the time of default than initially estimated. The borrowing firm was a small start-up, so it was not likely rated. There were no goods or services rendered in this case. In addition, there is no mention of recovery. This is also an example of credit risk arising from default on a financial obligation.

2. **D** There are four primary components of credit risk evaluation: (1) the borrower's (obligor's) willingness and capacity to repay the loan, (2) the effect of external conditions on the borrower's ability to repay the loan, (3) the inherent characteristics of the credit instrument and the extent to which the characteristics affect the borrower's willingness and ability to repay the loan, and (4) the quality and adequacy of risk mitigants such as collateral and loan guarantees. In this case, the local business environment, Justice's character, his payment history, and the business's financial positions are all relevant. While risk mitigants such as collateral and loan guarantees are part of credit analysis, it is unlikely that a local car dealer who has been in business for 20 years would be seeking a loan guarantee from a friend or family member. In addition, even if Justice were looking at a potential loan guarantor, Gulick would not simply evaluate his "friends and family" but would evaluate the specific person or business that intended to guarantee the loan.

3. **B** Name lending is a qualitative technique that is sometimes used to take the place of financial analysis. It is a technique used to evaluate the borrower's willingness to repay a financial obligation.

4. **B** Current measures used to evaluate credit risk include the firm's probability of default, which is the likelihood that a borrower will default; the loss given default, which represents the likely percentage loss if the borrower does default; the exposure at default; and the expected loss, which is, for a given time horizon, calculated as the product of the PD, LGD, and EAD. The stated 75% loss if the borrower defaults is the loss given default or LGD.

5. **A** Bank of the Plain States is insolvent because capital is wiped out. However, the bank has not failed because it is still operating with liquidity from the correspondent bank and the Federal Reserve. Therefore, the bank is insolvent but not failed.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

The Credit Analyst

Topic 17

Exam Focus

This topic focuses on the role and tasks performed by a banking credit analyst. For the exam, understand the objectives of the analyst (e.g., risk management, investment selection) as well as the difference between primary and secondary research. In addition, know the quantitative and qualitative skills that an analyst must possess in order to be successful. Finally, be able to recognize and describe the key information sources used by credit analysts such as the annual report, auditor's report, and company financial statements.

Credit Analyst Roles

LO 17.1: Describe, compare and contrast various credit analyst roles.

There are several methods to describe, compare, and contrast the various credit analyst roles, including:

- Job descriptions (e.g., consumer credit analyst, credit modeling analyst, corporate credit analyst, counterparty credit analyst, credit analysts at rating agencies, sell-side/buy-side fixed-income analysts, bank examiners and supervisors).
- Functional objective (e.g., risk management vs. investment selection, primary vs. secondary research).
- Type of entity analyzed (e.g., consumer, corporate, financial institution, sovereign/municipal).
- Classification by employer (e.g., banks and other financial institutions, institutional investors, rating agencies, government agencies).

Job Description

Brief descriptions of typical analyst roles provide a general understanding and an appreciation for the wide range of available roles.

Consumer Credit Analyst

- An administrative role with little opportunity for detailed analysis, data entry duties for loans that are then scored electronically (i.e., the relative score will determine status as approved or declined).
- Primarily works with individual consumer mortgages, with a key objective that all documentation is in place for approved loans.
- Large dollar loans referred by analyst to more senior personnel.

Credit Modeling Analyst

- A more quantitative role focused on the electronic scoring system described previously; some interaction with risk management personnel.
- Developing, testing, implementing, and updating various consumer credit scoring systems.

Corporate Credit Analyst

- Scope of analysis is limited to corporations (i.e., no financial institutions or sovereign credits).
- Some duties developing credit risk models may be required.

Counterparty Credit Analyst

- Analyzes typical counterparties (i.e., banks, nonbanks—brokers, insurance companies, hedge funds); usually employed by a financial institution to analyze other institutions with which it contemplates a two-way transaction.
- Performs credit reviews, approves limits, and develops/updates credit policies and procedures.
- Review process is often detailed requiring the following: (1) capital structure analysis (i.e., debt, equity), (2) financial statement analysis, (3) qualitative analysis of counterparty, and (4) qualitative analysis of the operating sector of counterparty.
- Finally, an internal rating is assigned and the analyst may also be required to comment on any of the following: (1) recommended limits to set on certain credit risk exposures, (2) approval or denial of a given credit application, and (3) recommended changes to the amounts, tenor, collateral, or other provisions of the transaction.

Credit Analysts at Rating Agencies

- Provide unbiased external ratings on bonds and other debt instruments issued by financial institutions, corporations, and governments.

Sell-Side and Buy-Side Fixed-Income Analysts

- Employed by financial institutions or hedge funds.
- In addition to credit risk, there is a focus on the relative value of debt instruments and their attractiveness as investments.

Bank Examiners and Supervisors

- Assessing the financial stability of financial institutions within a supervisory (risk management) role.

Functional Objective

Most credit analysts are employed to evaluate credit risk as part of an entity's overall risk management function. At the same time, others are employed for security selection and investment opportunity purposes. In terms of the amount and nature of work performed by analysts, there is a distinction between performing primary research versus secondary research.

Risk Management

Credit risk management is the most common functional objective, and it occurs in both the private and public sector. Credit risk analysts in the public sector will perform research on potential counterparties. The output of the research typically consists of internal use credit reports on the counterparties as well as recommendations as to which deals to accept and the appropriate risk limits. Bank examiners operate in the public sector in a regulatory capacity by reviewing the credit risk of certain financial institutions. Within that role, two key risk management objectives for the financial system are to ensure it is robust and to promote depth and liquidity.

Investment Selection

Investment selection is a much less common functional objective. Generally, credit analysts examine fixed-income securities with a focus on the risk of default. Specifically, an analyst must assess the likelihood of a given investment deteriorating in credit quality, thereby increasing credit risk and resulting in a decline in value. Additionally, a fixed-income analyst must also focus on the relative value of the investment. Relative value refers to the attractiveness of a given debt security compared to similar securities (e.g., other debt issues with the same asset class or same rating).

Rating Agency

The work of rating agency analysts is used for both risk management and investment selection purposes. The analysts examine issuers, counterparties, and debt in generally the same manner as credit risk analysts in the public sector.

Primary Research

Primary research refers to analyst-driven credit research or fundamental credit analysis. This is usually detailed (and often time-consuming) research with human effort that is both quantitative and qualitative in nature. The analysis looks at microeconomic factors (specific to the entity) and macroeconomic factors (e.g., political, industry). Rating agency analysts provide value by performing detailed credit analysis and arriving at independent conclusions, all of which is subsequently relied upon by other analysts. One of the disadvantages of primary research is its high cost; as a result, some financial institutions have an automated credit scoring system for simpler and less expensive transactions.

Secondary Research

It is often difficult for the credit analyst to perform detailed first-hand analysis (e.g., in-person visits), especially if the counterparty is very large or is located in a foreign country. An alternative is to perform secondary research, which involves researching the ratings provided by other rating agency analysts. Such information is combined with other relevant information sources, current information about the counterparty, and the analyst's own research, to conclude the counterparty's credit risk assessment. Given the reliance on other research, secondary research reports tend to be much shorter than primary research reports.

The goal of using secondary research is for a financial institution to perform counterparty credit analysis in a quick and efficient manner while maintaining reliability.

Type of Entity Analyzed

Corporate Credit Analyst

This role focuses on analyzing firms that are not financial institutions, notable examples being manufacturing firms or service providers. The purpose of the analysis is to assess the level of the firm's credit risk. That assessment is then used in deciding whether or not an entity would conduct business with, lend money to, or purchase securities of the other firm. In general, such analysis is very specialized based on the industry as well as focused on specific transactions.

Although the basic analytical principles are the same, there is huge diversity in the sectors, products, size, and geographic locations of the firms being analyzed. As a result, the corporate credit analyst must possess specific industry knowledge in order to be effective. An analyst will generally focus on only one or two industries, especially among fixed-income and rating agency analysts (given their need to perform detailed primary research).

Common sectors analyzed include the following: (1) real estate, (2) chemicals, (3) energy, (4) utilities, (5) telecommunications, (6) natural resources, (7) paper and forest products, and (8) automotive.

Another point of consideration is the size of the firm being analyzed. With a large public company, there may be a lot of public information available that would only necessitate secondary research, thereby reducing costs. With a smaller private company, less information is likely available, and as a result, more due diligence and primary research would be required, thereby increasing costs.

Finally, cash flow analysis is key to assessing corporate credit risk, so corporate analysts must also be equipped with strong accounting and financial statement analysis skills.

Bank and Financial Institution Credit Analyst

Counterparty credit analysts are employed by banks and other financial institutions and focus on analyzing the creditworthiness of other banks and other financial institutions. Compared to corporate credit analysis, the objective is not to make a lending decision but to determine whether the entity being analyzed is sufficiently creditworthy to function as a counterparty in future two-way transactions, with the entity requesting the analysis. Counterparty analysts could also establish exposure limits or decide whether to transact with the potential counterparty.

Both the nature of the financial instrument(s) and the length of time (tenor) of proposed contracts have a direct impact on the potential losses, and, as a result, have a direct impact on the type of analysis to be performed. Common financial instruments involved in counterparty transactions include (1) unsecured debt through the interbank market, (2) repurchase (repo) or reverse repurchase (reverse repo) transactions, (3) receivables factoring, (4) foreign exchange, and (5) derivatives.

Sovereign/Municipal Credit Analyst

Sovereign credit analysts determine the risk of default by foreign governments on borrowed funds. Primarily, sovereign credit analysts need to consider macroeconomic indicators in determining a government's ability to repay its debts. Additionally, political risk is an important consideration; the analyst attempts to gauge political stability and its impact on the ability to repay. Sovereign credit analysts examine the risks involved with specific international transactions or transactions with specific countries, provinces, states, or cities.

The stability of a given country's banking system strongly correlates with the ability of a country's government to repay foreign debt. The correlation also means that a government's financial stability impacts its banking system. Therefore, when analyzing the credit risk of foreign banks, analysts must place a lot of emphasis on sovereign risk. The obvious component of sovereign risk would include an analysis of the foreign country's debt-issuing ability in addition to the securities already issued. Another component would include an analysis of the impact of the country's general operating environment on its banking environment.

Classification by Employer

Banks, Nonbank Financial Institutions, and Institutional Investors

Credit analysts are most frequently employed by banks. Amongst all three groups, credit analysts usually function either within a risk management or an investment selection role.

Rating Agencies

Credit analysts employed by rating agencies analyze banks, corporations, and governments to determine their creditworthiness. Analysis includes the following steps:

Step 1: A general analysis of the credit risk of the entity.
Step 2: An analysis of issued securities and their impact on credit risk.
Step 3: An overall rating recommendation for the entity (communicated through rating symbols that are widely recognized and understood).

The information provided by the rating agencies is used by investors and risk personnel in making decisions regarding lending amounts, lending rates, and investment amounts.

Government Agencies

A typical role is a regulatory one, whereby the credit analyst analyzes a bank or insurance company to determine its level of risk, financial stability, and whether it meets the regulatory requirements to continue operating. A lesser-known role is when the government acts as an investor or lender, whereby the credit analyst has similar functions (i.e., investment selection or a risk management focus) to its counterparts in other organizations.

Rating Advisor

This is a unique role most frequently found in investment banks. The rating advisor has likely been a rating agency analyst and is now working to help a debt issuer obtain the highest rating possible. The rating advisor would perform an independent credit analysis of the issuer to arrive at a likely rating. The advisor would then provide advice to the issuer on how to mitigate any issues and respond to rating agency questions.

Banking Credit Analyst Tasks

LO 17.2: Describe common tasks performed by a banking credit analyst.

There are three main types of banking credit analysts: (1) counterparty credit analyst, (2) fixed-income analyst, and (3) equity analyst. Common tasks for each type of analyst are described in the following.

Counterparty credit analysts perform risk evaluations (reports) for a given entity. The triggering event to perform such evaluations may be an annual review of the entity or an intent to engage in an upcoming transaction with that entity. The tasks might be limited to simply covering certain counterparties or even only certain transactions or might be expanded to include decision making, recommendations on credit limits, and presenting to the credit committee.

Should the duties extend into the decision-making process, responsibilities would include the following: (1) authorizing the allocation of credit limits, (2) approving credit risk mitigants (i.e., guarantees, collateral), (3) approving excesses or exceptions over established credit limits, and (4) liaising with the legal department regarding transaction documentation.

Some analysts may be required to review and propose amendments to the bank's existing credit policies. With the implementation of the extensive regulatory requirements of Basel II and Basel III, credit analysts are now responsible for a wider range of regulatory compliance tasks.

Finally, counterparty credit analysts must understand the risks inherent with specific financial products and transactions. Therefore, it is necessary to obtain knowledge of the bank's products to supplement their credit decisions.

In an effort to make profits for the entity, **fixed-income analysts** provide recommendations regarding the decision to buy, sell, or hold debt securities. Therefore, they must ascertain the relative value to determine whether the security is undervalued, overvalued, or correctly valued. Both fundamental and technical analyses are generally performed in arriving at investment decisions. Fundamental analysis focuses on default risk while technical analysis focuses on market timing and pricing patterns. In making an investment decision, fixed-income analysts consider the ratings for specific debt securities issued by the rating agencies. The ratings provide reliable input in computing the relative value of securities.

Equity analysts analyze publicly traded financial institutions to help in determining whether an investor should buy, sell, or hold the shares of a given financial institution. When performing valuations, there is an emphasis on using return on equity (ROE). ROE takes into account both profitability and leverage. Other types of analysts would look at a wider range of financial ratios dealing with a bank's asset quality, capital strength, and liquidity. Equity analysts usually perform company valuations based on unaudited projections (while other analysts usually use audited historical data). Similar to fixed-income analysts, there are two general approaches to equity analysis. Analysts could choose to perform fundamental analysis, technical analysis, or a combination of the two.

Banking Credit Analyst Skills

LO 17.3: Describe the quantitative, qualitative, and research skills a banking credit analyst is expected to have.

Quantitative skills are necessary to assist in determining the ability of the entity to repay debt. A banking credit analyst must be able to read and interpret financial statements in order to perform a wide range of ratio analysis. The ratios to be analyzed depend on which measures of financial performance are relevant (i.e., liquidity, solvency, profitability). For example, return on equity (ROE) is a commonly used measure because it considers efficiency and leverage in addition to profitability. Because of the standardized nature of financial performance measures, peer analysis (i.e., comparison with similar banks and financial institutions) is possible and can be used to compare financial results.

Analysts must also understand statistical concepts (e.g., sampling, confidence intervals, correlation) in order to properly interpret data to arrive at reasonable conclusions under uncertainty. An example of a statistical analytical tool would be trend analysis (comparison of current year performance to past performance). The ability to analyze asset quality is also important. For example, a banking credit analyst could quantitatively assess a bank's loan portfolio by computing nonperforming loan ratios. Finally, analysts should have an understanding of monetary policy and an ability to compute and interpret macroeconomic data (e.g., GDP growth rates), both of which impact the general banking industry.

Qualitative skills are necessary to assist in determining the willingness of the entity to repay debt (e.g., reputation, repayment track record). It is critical for analysts to think beyond numbers and apply considerable judgment, reasoning, and experience in determining which factors are relevant for making decisions (e.g., management competence, bank's credit culture, and the robustness of credit review process).

The ability to analyze the quality, reliability, and consistency of reported earnings is also necessary. In addition, an understanding of the regulatory environment of banks and the impact(s) of any regulatory changes is important (e.g., central bank given more authority to regulate banks).

An analyst should have basic **research skills** in order to analyze an unfamiliar banking sector. Some preliminary research on overall sector structure, sector characteristics, and nature of regulation should be performed first. Then a reasonably detailed review of the largest banks followed by smaller banks may be performed. Examining larger banks first provides a basis of comparison when subsequently looking at smaller banks. After gaining a

thorough understanding of the banking sector, a bigger-picture perspective might be taken. For example, an analyst might try to research the country's entire banking sector, making note of the dominant entities and their impact on the sector.

A rating agency analyst would most frequently utilize **primary** research skills while a counterparty credit analyst would most frequently utilize **secondary** research skills.

Primary research skills include detailed analysis of (audited) financial statements for several years together with annual reports and recent interim financial statements. In addition, the rating analyst would usually need to make one or more due diligence visits to the bank to meet with senior management to discuss operational and business strategy. In addition to the visit, a questionnaire may also be provided to management to complete and return to the analyst.

Secondary research skills involve using the research published by others (e.g., rating agencies). The counterparty credit analyst would not make frequent visits to banks. Any site visits would tend to be brief and focused on very specific areas.

Information Sources

LO 17.4: Assess the quality of various sources of information used by a credit analyst.

Annual Report

Although there is likely bias on the part of management to present the entity in the most favorable way, the annual report does contain some useful information about culture, strategy, company performance, and economic outlook in the Management Discussion and Analysis (MD&A). Other information pertaining to regulation, such as changes to accounting or banking rules, may also be present in the annual report.

Auditor's Report

The auditor of a bank's financial statements is usually a major international accounting firm, and the staff on the audit engagement would possess specialized knowledge of the accounting rules pertaining to banks in order to successfully audit the bank in question.

The auditor provides an independent opinion on the bank's financial statements. If an **unqualified opinion** (or clean opinion) is provided, then it means that the auditor accepts the financial statements prepared by management as meeting the minimum standards of presentation (i.e., no material misstatements). The opinion assumes that management has provided the auditors with accurate information. Because of the cost-benefit tradeoff of analyzing every single item, auditors utilize a sampling approach and/or focus on high-risk areas during the testing phase. As a result, the financial statements may not be perfect or 100% accurate, but they present a reasonable indication of the financial performance for the stated period (income statement) and financial condition at a given point in time (balance sheet). In addition, it is not the auditor's responsibility to detect fraud committed by the

audited bank. It is up to the analyst to verify that an unqualified opinion has been issued and to watch for any exceptions from the standard wording of an unqualified opinion.

Analysts should be cautious when a qualified opinion is issued. With a qualified opinion, the auditors are saying that the financial statements might not fairly represent the company's financial performance and condition. The wording will be clear in the final paragraph of the report, with the existence of the word *except*. Common reasons for a qualified opinion include (1) substantial doubt as to the bank's ability to continue as a going concern, (2) a specific accounting treatment used by management is inconsistent with accounting rules, and (3) significant amounts of related-party transactions. It is up to the analyst to investigate and determine the exact nature of the qualification, its severity, and its impact on the analyst's overall assessment.

Rarely will the auditors issue an **adverse opinion** where they state that the financial statements do not fairly present the bank's financial performance and condition.

Sometimes there will be a change in auditors, and it is up to the analyst to inquire and determine if the change was valid. For example, sometimes management will dismiss its auditors because of a disagreement over one or more accounting treatments or the auditor's unwillingness to provide an unqualified opinion. The analyst should generally look upon those situations unfavorably. Alternatively, it is sometimes mandatory in some countries for a change in auditors every few years because they may have developed a comfortable relationship with the audited entity, preventing them from demonstrating independence and objectivity. In such a situation, the change in auditors is valid.

Financial Statements—Annual and Interim

The financial statements generally consist of the (1) balance sheet, (2) income statement, and (3) statement of cash flows. The balance sheet documents the net worth of the bank at a given point in time (e.g., year-end), and the income statement provides a quantification of performance over the period (e.g., net income for the year). The statement of cash flows is very useful for analyzing nonfinancial entities but not useful for bank credit analysis. An additional item, the statement of changes in capital funds, is useful for bank credit analysis (and regulatory purposes) because it explains changes in capital levels.

Supplementary footnotes to the financial statements may be included that provide more detail on specific items (e.g., off-balance sheet items such as leases and accounting policies).

Interim financial statements may be issued quarterly or semiannually, and they provide more timely financial information that would be useful to an analyst in making a current assessment of the bank.

Bank's Website

On the bank's website, the analyst is often able to find valuable information such as the annual report, financial statements, press releases, and background information. The quality, layout, and ease of accessibility of the website itself are often good indications of the stability of the bank.

News, the Internet, Securities Pricing Data

The analyst should check for any significant subsequent events (e.g., mergers, acquisitions, or new regulations) occurring after the corporate year-end that might not be covered in the annual report.

Proprietary electronic data services such as Bloomberg or a simple web search may provide necessary data on current bond and equity prices (especially for public listings or debt offerings).

Prospectuses and Regulatory Filings

Prospectuses and regulatory filings tend to minimize the discussion of the benefits of the investment and emphasize more of the potential risks so they could provide some useful information. Notably, prospectuses for equity and international debt issues may provide an effective resource.

Rating Agency Reports and Other Third-Party Research

As stated previously, counterparty credit analysts will find the rating agency reports most useful for their analysis. Other third party research includes investment reports from regulatory agencies and equity analysts.

Key Concepts

LO 17.1

Common credit analyst roles include consumer credit, credit modeling, corporate credit, counterparty credit, rating agency, fixed income, and bank examiner/supervisor. The roles are generally risk management in nature, although the fixed-income credit analyst focuses on investment selection. Primary and/or secondary research methods may be applied, and analysts could be analyzing nonfinancial entities, financial institutions, or sovereigns. Credit analysts are generally employed by banks, nonbank financial institutions, institutional investors, rating agencies, or government agencies.

LO 17.2

A counterparty credit analyst may perform risk evaluations of a given entity on a transaction-by-transaction basis or through an annual review. At times, the duties may extend into decision making (e.g., authorizing credit limits, suggesting guarantees and collateral, authorizing excesses). Additionally, there may be duties related to examining and amending the bank's existing credit policies and compliance tasks related to Basel II and III.

Fixed-income and equity analysts provide recommendations whether to buy, sell, or hold securities. Both types of analysts use fundamental and/or technical analysis techniques. Fixed-income analysts focus on determining relative value while equity analysts focus on determining return on equity.

LO 17.3

As a fundamental skill, banking credit analysts should be able to read and interpret financial statements in order to perform ratio analysis. They should also have a reasonable background in statistical concepts, in order to properly process and analyze data, and in macroeconomics, in order to understand the given bank's performance within the context of the overall economic environment. Additionally, significant judgment and skill in choosing relevant information to analyze is required in order to capture the important qualitative elements of any analysis.

LO 17.4

The annual report, auditor's report, financial statements (annual and interim), bank's website, internet, rating agency reports, other third-party research, prospectuses, and regulatory filings are some of the many available sources of information that may be used by a credit analyst. The annual report, together with financial statements, is the usual starting point for the analyst. For example, a counterparty credit analyst will rely heavily on rating agency reports.

Concept Checkers

1. Richard Marshall, FRM, is a rating agency analyst who is currently performing financial statement analysis on a major bank. Which of the following financial statements would be least useful for bank credit analysis?
   A. Balance sheet.
   B. Income statement.
   C. Statement of cash flows.
   D. Statement of changes in capital funds.

2. Krista Skujins, FRM, is a bank credit analyst who is examining the financial statements of a bank. She notices that there is a paragraph noted in the auditor's report that states that although the auditors agreed with virtually all of the bank's accounting treatments of the financial statement items, the auditors did not agree with the bank's decision to treat some of the leases as operating leases instead of capital leases. Based on that information, which of the following audit report opinions has the auditor most likely issued?
   A. Adverse opinion.
   B. Denial of opinion.
   C. Qualified opinion.
   D. Unqualified opinion.

3. Which of the following statements regarding a banking credit analyst's skills is most likely correct?
   A. High earnings quality suggests that the bank is profitable.
   B. Peer analysis is facilitated by the standardized nature of financial performance measures.
   C. Although qualitative analytical skills are required, quantitative analytical skills are more important.
   D. In analyzing an unfamiliar banking sector, an analyst should start by performing detailed reviews of the major banks.

4. Which of the following types of credit analysts would most likely be performing fundamental and/or technical analysis on a day-to-day basis?
   A. Equity analyst only.
   B. Fixed-income analyst only.
   C. Counterparty analyst and equity analyst.
   D. Equity analyst and fixed-income analyst.

5. Which of the following statements regarding the role of a corporate credit analyst is most likely correct?
   A. Earnings analysis is by far the most important analyst task.
   B. The larger the size of the firm, the lower the cost of analysis.
   C. Analysts are generally required to cover multiple industry areas given the huge diversity among corporations.
   D. The smaller the firm, the lower the cost of analysis.

Concept Checker Answers

1. **C** Although the statement of cash flows is most useful for analyzing nonfinancial entities (uses of cash and sources of cash differentiated between operating, investing, and financing), it is not useful for bank credit analysis.

2. **C** This situation is one where a specific accounting treatment used by the bank's management is inconsistent with the accounting rules. It is an isolated instance and so a qualified opinion would most likely be issued.

3. **B** Peer analysis refers to the comparison (financial and creditworthiness) of a subject bank to similar banks and financial institutions.

   High earnings quality does not necessarily mean a bank is profitable. Earnings quality refers to the reliability and consistency of the reported earnings.

   Quantitative and qualitative analytical skills are equally important and serve different (but related) purposes; qualitative skills are necessary to assist in determining the *willingness* of an entity to repay debt while quantitative skills are necessary to assist in determining the *ability* of an entity to repay debt.

   In analyzing an unfamiliar banking sector, the analyst should start with preliminary research on the overall structure, characteristics, and nature of regulation. After that, a detailed review of the largest (followed by smaller) banks could be performed.

4. **D** Both fixed-income analysis and equity analysis can be divided into two broad approaches: fundamental and technical analysis. Those approaches are valid because both types of analysts have the objective to earn profits for their respective employers and/or clients. In contrast, counterparty credit analysts are not likely to use either approach and are more focused on performing risk evaluations and possibly making some decisions on granting credit.

5. **B** With a large public company, there may be a lot of publicly available information that would only necessitate secondary research, thereby reducing costs. With a smaller private company, less information is likely available, and, as a result, more due diligence and primary research would be required, thereby increasing costs.

   Although the basic analytical principles are the same, there is huge diversity in the business sectors, products, size, and geographic locations of the firms being analyzed. As a result, the corporate credit analyst must possess specific industry knowledge in order to be effective. An analyst will most likely focus on only one or two industry areas.

   Corporate credit analysts specifically analyze firms that are NOT financial institutions.

   Cash flow analysis, not earnings analysis, is key to assessing corporate credit risk.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Classifications and Key Concepts of Credit Risk

Topic 18

Exam Focus

In this topic, we look at the various classifications of credit risk, how to measure individual and portfolio credit risks, and how to apply risk-adjusted pricing when making credit decisions. For the exam, be able to distinguish between default-mode valuations (default, recovery, and exposure risks) and value-based valuations (migration, spread, and liquidity risks). Also, understand the differences between expected and unexpected losses, since they have materially different implications on risk expectations and measurement. Value at risk (VaR), marginal VaR, and concentration risks are important measures of unexpected losses. Finally, understand risk-adjusted pricing, and be ready to interpret and calculate risk-adjusted return on risk-adjusted capital.

The Role of Credit Ratings

LO 18.1: Describe the role of ratings in credit risk management.

Credit ratings measure a borrower's creditworthiness. They are critical in ensuring that (1) borrowers can access capital markets, (2) the various risks of value creation are appropriately managed, and (3) the economic performance of business units can be compared.

Classifications of Credit Risk

LO 18.2: Describe classifications of credit risk and their correlation with other financial risks.

The concept of **credit risk** encompasses a range of risk measures. Those relating to *default* include default risk, recovery risk, and exposure risk. Those relating to *valuation* include migration risk, spread risk, and liquidity risk. Additional measures include concentration risk and the correlation with pure financial risks (e.g., interest rate, exchange rate, and inflation risks).

Default risk, or counterparty risk, relates to a borrower's inability to make promised payments. **Recovery risk** is the risk that the recovered amount, in the event of default, is less than the full amount that is due. **Exposure risk** measures the risk that a credit exposure at the time of default increases relative to its current exposure.

Migration risk looks at the risk that the credit quality and market value of an asset or position could deteriorate over time. To mitigate this risk, a periodic assessment of the credit quality of assets is necessary, and institutions may need to make credit provisions and record gains and losses. **Spread risk** is the risk that spreads may change during adverse market conditions as investors require different risk premiums, leading to gains and losses. **Liquidity risk** is the risk that asset liquidity and values deteriorate during adverse market conditions, lowering their market value.

LO 18.3: Define default risk, recovery risk, exposure risk and calculate exposure at default.

Default Risk

As mentioned, default risk relates to a borrower's inability to make promised payments. Determining the **probability of default** (PD) can be based on the following approaches:

- *Analyzing historical default frequencies of a borrower's homogenous asset classes.* Historically, credit analysis was based on subjective analysis, and rating agencies assigned ratings and historical default rates on past observations on an ex post basis (i.e., after an event).
- *Using mathematical and statistical tools.* Statistical models are typically used for large portfolios with hundreds or even thousands of positions, which allows for segmentation into different risk classes, measuring risk on an ex ante basis (i.e., before an event).
- *Using a hybrid approach that combines mathematical and judgmental analyses.* The mathematical results are generated automatically, which are then corrected using qualitative analysis.
- *Extracting implicit default probabilities from market prices of publicly listed counterparties.*

Default risk is typically measured over one year, although measuring cumulative probabilities of default beyond one year is also important. Shorter exposures are also exposed to default risk. For example, overnight lending will have a non-zero default probability due to unexpected shocks.

Recovery Risk

Recovery risk measures the risk that the amount recovered, in the event of a default, is less than the full amount that is due. The recovery rate is a conditional metric expressed as a percentage which assumes that default has already occurred. It is the complement to **loss given default** (LGD) such that the recovery rate equals 1 – LGD. The amount of recovery depends on the following factors:

- *The type of credit contracts used and the relevant legal system.*
- *General economic conditions.* Firms operating in more volatile sectors may see larger swings in asset values.
- *Covenants.* Negative covenants restricting the sale of assets that are important to the borrower should be considered in LGD estimations.

Estimating the recovery rate on ex ante basis is complex due to the difficulty in collecting recovery rate data (including lost data) and problems with uniformity of information. Even when sophisticated techniques allow for the collection of good information, it is challenging

to create a comprehensive model. As a result, less sophisticated models, often using a top-down approach, are commonly used in determining LGD and recovery rates.

Exposure Risk

Exposure risk measures the amount of risk a firm is exposed to in the event of a default. For term loans, exposure is easily determined. For revolving credit facilities, determining exposure is more challenging since it depends on borrower behavior and external events. In this situation, exposure risk [i.e., **exposure at default** (EAD)] can be calculated as:

EAD = drawn amount + (limit – drawn amount) × LEQ

where:
drawn amount = amount of the credit facility currently used
limit = maximum amount granted by a bank to the borrower
LEQ = loan equivalency factor (rate of usage of available limit beyond ordinary use)

Other assets (e.g., accounts receivable) pose additional challenges, including events of noncompliance in contractually obligated terms and certain conditions which could alter the amounts due from the borrower. Determining EAD for derivatives contracts is also challenging since market conditions could alter the value of these contracts. In this case, EAD is calculated using stochastic models that forecast future events.

Credit Risk Measurement

LO 18.4: Explain expected loss, unexpected loss, VaR, and concentration risk, and describe the differences among them.

Expected loss (EL) calculates the average loss in the long run generated from credit facilities. The *EL rate* is a percentage of the EAD. EL can be determined on a financial basis, defined as a decrease in market value resulting from credit risk, or on an actuarial basis, ignoring credit risk and considering only losses from the EAD.

EL can be calculated as:

EL = PD × LGD × EAD

EL is determined based on expectations and is a cost that is incorporated into business and credit decisions. However, actual losses may be different from expectations, resulting in **unexpected losses** (ULs). ULs are problematic because they can jeopardize the viability of a bank as a going concern. Banks can prepare for ULs by holding sufficient equity capital to cover all risks, not just credit risks. Capital can be replenished from profits in good times, which can absorb ULs. Credit risk models and credit ratings are important in determining the overall credit contributions needed by banks.

In measuring UL, standard deviation is not an adequate measure since it assumes a symmetrical loss distribution. In practice, risks are often not symmetric, so other credit

measures, such as **value at risk** (VaR), are more useful. VaR is defined as a percentage of EAD and is calculated as the difference between the maximum loss at a certain confidence level and the EL at a given time horizon. For example, VaR at a 99% confidence level defines the capital that a bank must put aside to cover ULs in 99% of the cases. The bank's insolvency (due to catastrophic losses) is therefore confined to events whose probability does not exceed 1%.

As mentioned, credit risk probability distributions are asymmetric, where events with small probabilities (e.g., insolvency) may significantly impact a bank's profitability. **Credit risk models** can help estimate probability density functions. Loss distributions and calculating VaR measures can be done by (1) adopting a parametric closed-form distribution, (2) using numerical simulations, or (3) using discrete probability solutions.

Despite the usefulness of VaR and EL measures, these measures do not factor in portfolio concentration and typically ignore diversification between assets. Diversification reduces risk; therefore, the aggregate of individual risk measures does not equal portfolio risk. As a result, analyzing credit risk from a portfolio perspective should account for **concentration risk**. Concentration risk arises in credit portfolios where borrowers all face common risk factors, including interest rates, exchange rates, and changes in technology. Facing common risks is problematic since they simultaneously affect a borrower's willingness and ability to repay their obligations.

Banks traditionally avoided concentration risk by limiting their exposures to individual customers, and, thus, minimizing risk through higher granularity (i.e., a well-diversified portfolio). When analyzing with quantitative credit risk management, the need for granularity is already integrated into default correlations. Full portfolio credit risk models look at how much individual borrower risk factors contribute to concentration. They also enable segmentation of portfolio risk or viewing the entire portfolio risk profile as a whole. Portfolio credit risk models are critical in quantifying how much marginal risk can be attributed to various credit exposures. Without these models, it is not possible to properly quantify risks.

Default codependencies can be modeled through (1) asset value correlations and (2) default correlations. When modeling with **asset value correlations**, portfolios could be affected by external events, which influence counterparty values and could cause asset values to drop below the value of outstanding debt. Diversification is measured by considering the debt outstanding between two borrowers and by looking at the correlation among asset values.

Modeling with **default correlations** looks at historical correlations of data among homogenous borrower groups Since default correlations are generally not perfectly positively correlated, banks will have to separately address their potential losses in changing financial periods. This would allow banks to address risks in a more organized fashion, with less committed capital and smaller fluctuations in provisioning.

LO 18.5: Evaluate the marginal contribution to portfolio unexpected loss.

From a portfolio perspective, it is also important to measure how an individual exposure, or the addition of a new exposure, contributes to overall portfolio risk. One such measure is **marginal VaR**, which calculates the incremental portfolio risk from an individual exposure. The marginal contribution can be calculated as:

$$ULC_i = \frac{\partial UL_{portfolio}}{\partial w_i} w_i$$

This measure can be expressed under the Markowitz mean-variance framework as:

$$ULC_i = \rho_{i,portfolio} \times w_i \times UL_{portfolio}$$

where:
ULC_i = marginal contribution of the i^{th} loan portfolio unexpected loss
$\rho_{i,portfolio}$ = default correlation between the i^{th} loan and the overall portfolio
w_i = weight of the i^{th} loan in the overall portfolio
$UL_{portfolio}$ = portfolio unexpected loss

A practical interpretation of marginal contribution comes from calculating betas. For example, the beta of the i^{th} loan can be valued by rearranging the previous formula as follows:

$$\beta_i = \frac{ULC_i \,/\, w_i}{UL_{portfolio}}$$

We can interpret this measure as the marginal risk contribution from the i^{th} loan relative to the average portfolio risk. A beta greater than one would imply that the marginal risk from the i^{th} loan is greater than the average portfolio risk and would, therefore, increase portfolio concentration risk. A beta less than one would reduce portfolio risk and increase the effect from diversification. With this measure, loans can be quickly selected based on their betas in order to identify which loans would lead to portfolio concentration or diversification.

Risk-Adjusted Pricing

LO 18.6: Define risk-adjusted pricing and determine risk-adjusted return on risk-adjusted capital (RARORAC).

As VaR increases, so does the expectation of higher returns and economic capital. The cost of capital multiplied by VaR needs to be incorporated into lending decisions as a cost for banks that are price takers, or as a lending cost (to be included in credit spreads) for banks that are price setters.

Economic capital is important from a pricing perspective and should, therefore, be incorporated into loan pricing decisions. While, in theory, price is an external factor and banks are price takers in an integrated market, in reality, markets are segmented, so pricing decisions vary. For example, in the wholesale market, banks are typically price takers,

whereas in retail markets, banks are price setters (due to information asymmetries and costs). Regardless of the market, prices are an important component of credit decisions and loan pricing. For banks, risk-based pricing policy is important for (1) active portfolio management (by using credit derivatives), (2) integrating credit, market, and operational risks into risk budgeting, and (3) setting management objectives.

The **risk-adjusted return on capital** (RAROC) has been widely used by banks in measuring risk-adjusted performance. A common variant of RAROC is the **risk-adjusted return on risk-adjusted capital** (RARORAC). Both of these measures are used by business lines to assess whether returns generated exceed the market risk premium required by capital. The market risk premium should be in proportion to the credit spread. Transactions create value if RARORAC exceeds a minimum target, for example, a target return on equity (ROE):

$$\text{RARORAC} > \text{ROE}_{\text{target}}$$

Applied in the context of **economic value added** (EVA), which is a measure of the firm's economic profit, EVA can be determined as the risk premium of economic capital, where K_e is the cost of shareholder capital:

$$\text{EVA} = (\text{RARORAC} - K_e) \times \text{economic capital}$$

The pricing of credit products should include fundamental variables, including costs and potential losses. Therefore, RARORAC should incorporate funding cost, EL (to cover loan provisions), allocated economic capital, and excess return required by shareholders (with respect to the cost of funding). In simple form, RARORAC can be calculated as:

$$\text{RARORAC} = \frac{\text{spread} + \text{fees} - \text{EL} - \text{cost of capital} - \text{cost of operations}}{\text{economic capital}}$$

Firms can make certain exceptions to override credit decisions for relationship or reputational reasons. For example, a bank may decide to maintain ties with an otherwise unprofitable customer for reputational or relationship reasons. These decisions should be made at the senior management level.

In general, credit decisions and outcomes, as well as customer profitability analysis, should be communicated to senior management. The goal of such analysis is to generate a comprehensive view of customer profitability, costs, revenues, and risks by segmenting customers, with the aim of identifying profitable and unprofitable relationships. Capital currently set aside for unprofitable or marginally profitable customers could then be freed up and allocated to more profitable opportunities. The relative risk-adjusted profitability models of customers are important in optimizing the risk-return decisions regarding bank portfolios. These models have gained more traction recently because of the growth in investor sophistication, and the growth in size and complexity of banking groups, which now have a greater need for risk-adjusted performance measures.

Key Concepts

LO 18.1

Credit ratings measure a borrower's creditworthiness. Ratings enable borrowers to access capital markets and properly manage risks.

LO 18.2

There are several classifications of credit risk. Risks relating to default include default risk, recovery risk, and exposure risk. Risks relating to valuation include migration risk, spread risk, and liquidity risk. Credit risk also encompasses concentration risk and can be correlated with pure financial risks.

LO 18.3

Determining default probability can be based on (1) analysis of historical default frequencies of a borrower's homogenous asset classes, (2) mathematical and statistical tools, (3) a hybrid approach that combines mathematical and judgmental analyses, and (4) implicit default probabilities from market prices of publicly listed counterparties.

Default risk is typically measured over one year. However, cumulative default rates extending beyond one year are important. Shorter exposures, such as overnight lending, are also exposed to default risk.

Recovery risk is a conditional metric assuming that default has already occurred. The amount of recovery depends on (1) the type of credit contracts used and the relevant legal system, (2) general economic conditions, and (3) covenants. Estimating the recovery rate on ex ante basis is challenging due to the difficulty in collecting recovery rate data, uniformity of information, and challenges in creating a comprehensive model.

Exposure risk is easily determined for term loans. For revolving credit facilities, exposure depends on borrower behavior and external events. In this case, exposure risk [i.e., exposure at default (EAD)] can be calculated as:

$$\text{EAD} = \text{drawn amount} + (\text{limit} - \text{drawn amount}) \times \text{loan equivalency factor}$$

LO 18.4

Expected loss (EL) is the average loss generated from credit facilities. EL can be calculated as:

$$\text{EL} = \text{PD} \times \text{LGD} \times \text{EAD}$$

Unexpected losses (ULs) result from actual losses that may be different from expectations. The risk of ULs can be mitigated by holding sufficient equity capital.

Value at risk (VaR) measures are more useful in measuring unexpected losses than traditional volatility measures since loss distributions are not symmetric. VaR is computed as the difference between the maximum loss at a certain confidence level and the EL at a given time horizon.

Traditional risk measures, like VaR, do not account for concentration risk, which arises when borrowers are exposed to common risk factors which could simultaneously affect their willingness and ability to repay their obligations.

Concentration was traditionally mitigated by minimizing exposure to a single borrower. Portfolio credit risk models specifically factor in a borrower's risk contribution to concentration, and allow for segmentation of portfolio risk or viewing the portfolio risk profile as a whole.

Default codependencies can be modeled with (1) asset value correlations, which look at the influence of external events on asset values, and (2) default correlations, which look at historical correlations among homogenous borrower groups.

LO 18.5

Marginal VaR calculates the incremental portfolio risk from an individual exposure. Marginal VaR is useful in calculating betas, which can be interpreted as the marginal risk contribution from a loan to average portfolio risk. A beta greater than one implies concentration risk, while a beta less than one indicates diversification.

LO 18.6

The risk-adjusted return on risk-adjusted capital (RARORAC) is an important risk-adjusted performance measure used to assess whether returns generated exceed the market risk premium required by capital. Transactions add value as long as RARORAC exceeds a minimum target (e.g., a target return on equity).

Economic value added (EVA) measures economic profit and looks at the additional return generated relative to the cost of capital:

$$\text{EVA} = (\text{RARORAC} - K_e) \times \text{economic capital}$$

Concept Checkers

1. Which of the following credit risks best reflects the risk that an entity may have to accept lower-than-expected values for credit exposures that must be sold?
   A. Recovery risk.
   B. Exposure risk.
   C. Spread risk.
   D. Liquidity risk.

2. During a conversation about credit risk, a colleague mentions that the typical measure of default risk is the probability of default (PD) over a one-year horizon, because overnight lending has a zero PD. Is your colleague correct with respect to her statements?
   A. She is correct with respect to both statements.
   B. She is correct with respect to default risk over a one-year horizon only.
   C. She is correct with respect to overnight lending only.
   D. She is not correct with respect to either statement.

3. A credit analyst notes that value at risk (VaR) is a more useful measure than volatility of losses, because loss distributions tend to be asymmetric. The analyst further notes that VaR does not account for portfolio concentration risk. Is the analyst correct with respect to his statements?
   A. The analyst is correct with respect to both statements.
   B. The analyst is correct with respect to VaR as a more useful measure only.
   C. The analyst is correct with respect to concentration risk only.
   D. The analyst is not correct with respect to either statement.

4. Which of the following risks is most likely associated with marginal value at risk (marginal VaR)?
   A. Recovery risk.
   B. Spread risk.
   C. Concentration risk.
   D. Exposure risk.

5. A bank estimated that its risk-adjusted return on risk-adjusted capital (RARORAC) is 15%. The bank's marginal cost of capital is 7%, and its economic capital is $100 million. What is the bank's economic value added (EVA)?
   A. $7 million
   B. $8 million.
   C. $15 million.
   D. $22 million.

Concept Checker Answers

1. **D** Liquidity risk measures the risk that asset liquidity and values deteriorate during adverse market conditions, resulting in lower market value.

2. **B** The colleague's statement with respect to the PD being measured over a one-year time horizon is correct. She is incorrect with respect to her statement on overnight lending, which has a non-zero PD.

3. **A** The analyst is correct with respect to both of his statements. Value at risk (VaR) is a more useful measure than the standard deviation of losses, since loss risk distributions tend to be asymmetric. VaR, however, does not account for portfolio concentration risk.

4. **C** Marginal VaR is a measure of concentration risk, which measures the probability of loss arising from a borrower's exposure to common risk factors.

5. **B** EVA measures economic profit as the additional return generated relative to the cost of capital. EVA is calculated as:

   $\text{EVA} = (\text{RARORAC} - K_e) \times \text{economic capital}$

   $\text{EVA} = (0.15 - 0.07) \times \$100 \text{ million} = \$8 \text{ million}$

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Rating Assignment Methodologies

Topic 19

Exam Focus

The focus of this topic is on the assessment of default risk and assigning ratings as a means of quantifying this risk. For the exam, be comfortable with the relationship between default probability and ratings. Also, understand how ratings are derived for issues and issuers, how ratings migrate over time, how various default probabilities are calculated, and what defines a good ratings system. Default is predicted using many different approaches: experts-based (heuristic), reduced form (statistical and numerical), structural (the Merton model), linear discriminant analysis, logistic regression models, cluster analysis, principal component analysis, and cash-flow simulations. You should be familiar with the advantages and limitations of each of these approaches as well as the similarities and differences among them. These approaches are heavily quantitative, so it is critical to also factor qualitative information into any analysis of default probability.

Rating Systems

LO 19.1: Explain the key features of a good rating system.

Ratings play a critical role in supporting credit risk management. Ratings are also used to support credit pricing and capital provisions used to cover unanticipated credit losses. Given that defaults represent a significant source of losses for lenders, ratings are used to measure the probability of a default event occurring in a specific time horizon. Ratings are also used to support decisions made at various levels of an organization, as assessments are used to support a structured internal governance system. Ratings represent the most critical instrument used in modern and quantitative credit risk management. However, ratings must be as objective as possible—meaning different credit analysts using the same inputs and methodologies should reach similar ratings.

A good rating system will possess the following three features, which together will help entities measure the appropriateness of their internal rating systems:

- *Objectivity and Homogeneity*. An objective rating system will produce judgments based only on considerations tied to credit risk, while a homogeneous system implies that ratings are comparable among market segments, portfolios, and customer types.
- *Specificity*. A rating system is specific if it measures the distance from a default event while ignoring other financial elements that are not directly tied to potential default.
- *Measurability and Verifiability*. Ratings must provide correct expectations related to default probabilities which are backtested on a continuous basis.

Experts-Based, Statistical-Based, and Numerical Approaches

LO 19.2: Describe the experts-based approaches, statistical-based models, and numerical approaches to predicting default.

Although the consequences of default can be substantial, fortunately a default itself is a relatively rare occurrence (the default rate during deep recessions peaks in the range of 2% to 5%). A credit analyst whose job it is to assess the potential for default is typically an individual with a great deal of experience who can balance his knowledge with perception and intuition when evaluating default scenarios.

An early model for assessing default was created by Wilcox (1971)[1] using what was called "gambler's ruin theory." His model for predicting the probability of default was dependent on assessing the probability of gains and losses as well as the level of profits relative to a company's initial capital endowment. Another theory applied to corporate finance is the "point of no return theory," which implies that business operations must produce enough cash to cover required interest and principal payments on debt. As long as the operational flow of funds exceeds interest and principal payments needed, the company will be successful. The balance needed represents the no-return point, as a company can only be sustainable as long as it can meet its debt payments.

Credit quality analysis from an **experts-based approach** will apply frameworks such as the four Cs of credit (Character, Capital, Coverage, Collateral) proposed by Altman/NYU, LAPS (Liquidity, Activity, Profitability, Structure) from Goldman Sachs, and CAMELS (Capital Adequacy, Asset Quality, Management, Earnings, Liquidity, Sensitivity) from JP Morgan. As Porter (1980, 1985)[2,3] emphasized, qualitative features need to be factored into any analysis along with quantitative components.

A **statistical-based classification** centers on the fact that a quantitative model is essentially just a description of the real world within a controlled environment. Models are simply used to express a viewpoint of how the world will likely behave given certain criteria. A quantitative model will have a qualitative (formal) formulation that describes the basic view of the world we are trying to capture in the model; it will also have the underlying assumptions needed to build the model. The assumptions, which serve to simplify the process, should cover organizational behavior, possible economic events, and predictions on how market participants will react to these events. Statistical-based models are primarily focused on assessing the default risk associated with unlisted firms, even though they certainly can be useful in managing default risk for many other entities and organizations. Here, the model is based on quantitative and qualitative variables, as well as publicly unavailable and low-frequency data.

As will be described later in the topic, **numerical approaches** have the objective of deriving optimal solutions using "trained" algorithms and incorporating decisions based on relatively weak information in very complex environments. An example is a "neural network," which is able to continuously update itself for changes to the environment.

1. Wilcox, J. W. (1971), A Gambler's Ruin Prediction of Business Failure Using Accounting Data, *Sloan Management Review*, 12 (3).
2. Porter, M. (1980), Competitive Strategy, Free Press.
3. Porter, M. (1985), Competitive Advantage: Creating and Sustaining Superior Performance, Free Press.

Rating Migration Matrix

LO 19.3: Describe a rating migration matrix and calculate the probability of default, cumulative probability of default, marginal probability of default, and annualized default rate.

A migration frequency represents how often ratings change from one class to another. A **migration matrix** shows relative frequencies of counterparties that move from one rating class (shown in each row) to another class (shown in each column). Figure 1 shows a one-year Moody's migration matrix across a 30-year period (1970–2007), with WR representing withdrawn ratings.

Figure 1: One-Year Moody's Migration Matrix

		Final Rating Class (%)									
		Aaa	Aa	A	Baa	Ba	B	Caa	Ca-C	Default	WR
Initial Rating Class	Aaa	89.1	7.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	3.2
	Aa	1.0	87.4	6.8	0.3	0.1	0.0	0.0	0.0	0.0	4.5
	A	0.1	2.7	87.5	4.9	0.5	0.1	0.0	0.0	0.0	4.1
	Baa	0.0	0.2	4.8	84.3	4.3	0.8	0.2	0.0	0.2	5.1
	Ba	0.0	0.1	0.4	5.7	75.7	7.7	0.5	0.0	1.1	8.8
	B	0.0	0.0	0.2	0.4	5.5	73.6	4.9	0.6	4.5	10.4
	Caa	0.0	0.0	0.0	0.2	0.7	9.9	58.1	3.6	14.7	12.8
	Ca-C	0.0	0.0	0.0	0.0	0.4	2.6	8.5	38.7	30.0	19.8

It is worth noting that migrations are correlated and dependent transitions that occur over time (as opposed to being random walks). Observations over time have shown that when initial ratings are low (high), they become better (worse) than expected. However, default frequencies do have inherent limitations tied to the different applied methodologies of rating agencies. These limitations include differences in definitions, observed populations, amounts rated, and initial ratings.

Several key measures are used to assess the risk of default. The first is the **probability of default** (PD), which is shown in the following equation:

$$PD_k = \frac{\text{defaulted}_t^{t+k}}{\text{names}_t}$$

where:
PD = probability of default
defaulted = number of issuer names that have defaulted in the applicable time horizon
names = number of issuers
k = time horizon

A **cumulative probability of default**, given a sequence of default rates, can be calculated as follows:

$$PD_k^{cumulative} = \frac{\sum_{i=t}^{i=t+k} defaulted_i}{names_t}$$

Comparing the two previous equations, a **marginal probability of default** can be calculated as follows:

$$PD_k^{marginal} = PD_{t+k}^{cumulative} - PD_t^{cumulative}$$

Finally, the **annualized default rate** (ADR) can be computed for both discrete and continuous time intervals as follows:

$$\text{discrete: } ADR_t = 1 - \sqrt[t]{\left(1 - PD_t^{cumulative}\right)}$$

$$\text{continuous: } ADR_t = -\frac{\ln\left(1 - PD_t^{cumulative}\right)}{t}$$

Rating Agencies' Methodologies

LO 19.4: Describe rating agencies' assignment methodologies for issue and issuer ratings.

Rating agencies have a goal of running systematic surveys on all default risk determinants. In their approach, both judgmental and model-based analyses are integrated. Whereas a small component of revenues for rating agencies comes from selling information to market participants and investors, the vast majority of their revenues comes from counterparty fees. Because rating agencies are concerned with maintaining their reputations, and because the issuers who pay the rating agencies to rate them want to demonstrate the credit quality of their issues, the investment community (investors, buyers, and traders) can rely on the work of these agencies.

An agency will have potential access to privileged information, as they have a window into management's strategies and vision. To successfully assign a rating, an agency must have access to objective, independent, and sufficient insider information. As an example of the decision-making process for assigning a rating, Standard & Poor's has an eight-step process beginning with receiving a ratings request from an issuer and followed by the initial evaluation, meeting with management, analysis, a review and vote by the rating committee, a notification to the issuer, the dissemination/publication of ratings opinions, and continued monitoring of issuers and issues.

The final rating for a corporate borrower will come from two analytical areas: financial risks (accounting, cash flow, capital structure, etc.) and business risks (industry analysis, peer comparisons, company positioning relative to peers, country risk, etc.). As an example, in

assessing financial risks, Standard & Poor's focuses on coverage ratios, liquidity ratios, and profitability ratios. Higher margins equate to a safer financial structure and a higher credit rating for the borrower. This analysis is then merged with assessments of sovereign risk, the competitive environment of the issuer, and the strength of the business sector.

Along with the factors noted previously, additional analytical areas include firm strategy coherence and consistency, management's reputation and experience, profit and cash-flow diversity, the ability of an organization to address competitive needs, and the organization's resilience to business uncertainty and volatility. The quality of a firm's internal governance; exposures to legal, political, environmental, and institutional risks; technological sustainability; and potential liabilities tied to employees are all relatively new factors addressed in ratings analyses. It is worth noting that an entity can have favorable positions in some of these analytical areas and less-favorable positions in other areas without it negatively affecting ratings.

At this point, there are only three main international ratings agencies: Moody's, Standard & Poor's (S&P), and Fitch. Moody's focuses more on ratings for actual issuances themselves, as opposed to ratings for issuers. S&P focuses on ratings for issuers. Fitch provides issuer ratings based on potential defaults for publicly listed bonds (which ignore commercial and private bank borrowings). The obvious challenge is the lack of comparability among the agencies, although recent market pressures have led to agencies using more quantitative analyses that facilitate easier comparisons.

Borrower Rating and Probability of Default

LO 19.5: Describe the relationship between borrower rating and probability of default.

Based on the law of large numbers (i.e., a large number of trials will approximate the expected value) and the fact that with a homogeneous population, actual frequencies observed serve as strong predictors of central probabilities, default probabilities can be applied to estimate the future behavior of a population. Not surprisingly, what has been observed is that higher-rated issues have a lower probability of default. The highest-rated issues almost never default even over a period of 10 years, while the lowest-rated issues often default early on and are almost assured of default after a 10-year period.

Agencies' Ratings vs. Experts-Based Approaches

LO 19.6: Compare agencies' ratings to internal experts-based rating systems.

A rating agency's assignment processes will be different than the internal classification methods used by banks, even though the underlying processes are often analogous. Relative to a formal approach, such as quantitative analysis based on statistical models, experts-based approaches are neither considered to be inferior nor superior. An experts-based approach relying on judgment will require significant experience and repetitions in order for many judgments to converge. Also, the challenges of such an approach include the dynamic nature of organizational patterns; M&A activity, which blends portfolios and processes; and

changing company cultures. A predictive performance that may work in one period is not necessarily indicative of future performance. Also, internal credit rating systems are difficult and time-consuming to develop. However, having a reliable internal system represents a significant value added for an entity.

In terms of the criteria for a good rating system discussed earlier, the following comparisons can be made between agencies' ratings and internal experts-based rating systems:

- *Objectivity and Homogeneity*. Agencies' ratings are 75% compliant, while internal experts-based rating systems are 50% compliant.
- *Specificity*. Agencies' ratings are close to 100% compliant, while internal experts-based rating systems are 75% compliant.
- *Measurability and Verifiability*. Agencies' ratings are 75% compliant, while internal experts-based rating systems are 25% compliant.

Structural Approaches vs. Reduced Form Approaches

LO 19.7: Distinguish between the structural approaches and the reduced-form approaches to predicting default.

The foundation of a **structural approach** (e.g., the Merton model) is the financial and economic theoretical assumptions that describe the overall path to default. Under this approach, building a model involves estimating the formal relationships that link the relevant variables of the model. In contrast, **reduced form models** (e.g., statistical and numerical approaches) arrive at a final solution using the set of variables that is most statistically suitable without factoring in the theoretical or conceptual causal relationships among variables.

A reduced form model will not make any ex ante assumptions about causal drivers for default (unlike structural models); specific firm characteristics are linked to default, using statistics to tie them to default data. As such, the default event itself represents a real-life event. The independent variables in these models are combined based on their estimated contribution to the final result and can change in terms of relevance depending on firm size, firm sector, and economic cycle stage.

A significant model risk in reduced form approaches results from a model's dependency on the sample used to estimate it. To derive valid results, there must be a strong level of homogeneity between the sample and the population to which the model is applied.

Reduced form models used for credit risk can be classified into statistical and numerical-based categories. Statistical-based models use variables and relations that are selected and calibrated by statistical procedures. Numerical-based approaches use algorithms that connect actual defaults with observed variables. Both approaches can aggregate profiles, such as industry, sector, size, location, capitalization, and form of incorporation, into homogeneous "top-down" segment classifications. A "bottom-up" approach may also be used, which would classify variables based on case-by-case impacts. While numerical and statistical methods are primarily considered bottom-up approaches, experts-based approaches tend to be the most bottom up.

The Merton Model

LO 19.8: Apply the Merton model to calculate default probability and the distance to default and describe the limitations of using the Merton model.

The **Merton model**, which is an example of a structural approach, is based on the premise that the technical event of default occurs only when the proprietary structure of the defaulting company is no longer considered worthwhile. Assuming that a default event is dependent on financial variables, default probability can be calculated using the Black-Scholes-Merton formula. The five relevant variables include the market risk interest rate, the maturity (when the debt expires), the debt face value (similar to an option strike price), the value of the borrower's assets, and the volatility of the assets' value. The output provides the probability that the borrower will be insolvent.

In Merton's approach, the equity of a firm represents a call option on the market value of the assets. As such, the value of equity is a by-product of the market value and volatility of the assets, as well as the book value of liabilities; this implies that a firm's asset volatility serves as the link between its business and financial risk. A firm's risk structure is used to set its optimal financial structure, which in turn affects equity due to the probability of shareholders losing their investments due to default.

The default probability using the Merton approach and applying the Black-Scholes-Merton formula is as follows:

$$PD = N\left(\frac{\ln(F) - \ln(V_A) - \mu T + \frac{1}{2}\sigma_A^2 T}{\sigma_A \sqrt{T}}\right)$$

where:
ln = the natural logarithm
F = debt face value
V_A = firm asset value (market value of equity and net debt)
μ = expected return in the "risky world"
T = time to maturity remaining
σ_A = volatility (standard deviation of asset values)
N = cumulated normal distribution operator

In the preceding equation, the components that lie within the brackets are seen as a standardized measure of the "distance to the debt barrier." This distance represents a threshold beyond which a firm will enter into financial distress and subsequently default.

The **distance to default** (DtD) using the Merton approach (assuming T = 1) is as follows:

$$DtD = \frac{\ln(V_A) - \ln(F) + \left(\mu_{\text{risky}} - \frac{\sigma_A^2}{2}\right) - \text{"other payouts"}}{\sigma_A} \cong \frac{\ln V - \ln F}{\sigma_A}$$

There are many challenges associated with using the Merton model. Neither the asset value itself nor its associated volatility are observed. The structure of the underlying debt

is typically very complex, as it involves differing maturities, covenants, guarantees, and other specifications. Because variables change so frequently, the model must be recalibrated continuously. Also, its main limitation is that it only applies to liquid, publicly traded firms. Using this approach for unlisted companies can be problematic due to unobservable prices and challenges with finding comparable prices. Finally, due to high sensitivity to market movements and underlying variables, the model tends to fall short of fully reflecting the dependence of credit risk on business and credit cycles.

Professor's Note: The Merton model will be discussed in greater detail in the next topic (Topic 20).

Linear Discriminant Analysis

LO 19.9: Describe linear discriminant analysis (LDA), define the Z-score and its usage, and apply LDA to classify a sample of firms by credit quality.

A scoring model is a family of statistical tools developed from qualitative and quantitative empirical data that determines the appropriate parameters and variables for predicting default. **Linear discriminant analysis** (LDA) is one of the most popular statistical methods used for developing scoring models. An LDA-based model is a reduced form model due to its dependency on exogenous variable selection, the default composition, and the default definition. A scoring function is a linear function of variables produced by an LDA. The variables are chosen based on their estimated contribution to the likelihood of default and come from an extensive pool of qualitative features and accounting ratios. The contributions (i.e., weights) of each accounting ratio to the overall score are represented by **Altman's Z-score**. Although there are many discriminant analysis methods, the one referenced in this topic is the ordinary least squares method.

LDA categorizes firms into two groups: the first represents performing (solvent) firms and the second represents defaulting (insolvent) firms. One of the challenges of this categorization is whether or not it is possible to predict which firms will be solvent and which will be insolvent prior to default. A Z-score is assigned to each firm at some point prior to default on the basis of both financial and nonfinancial information. A Z cut-off point is used to differentiate both groups, although it is imperfect as both solvent and insolvent firms may have similar scores. This may lead to incorrect classifications.

Altman (1968)[4] proposed the following LDA model:

$$Z = 1.21x_1 + 1.40x_2 + 3.30x_3 + 0.6x_4 + 0.999x_5$$

where:
x_1 = working capital / total assets
x_2 = accrued capital reserves / total assets
x_3 = EBIT / total assets
x_4 = equity market value / face value of term debt
x_5 = sales / total assets

4. Altman, E. I. (1968), Financial Ratios, Discriminant Analysis and Prediction of Corporate Bankruptcy, *Journal of Finance*, 23 (4).

In this model, the higher the Z-score, the more likely it is that a firm will be classified in the group of solvent firms. The **Z-score cut-off** (also known as the *discriminant threshold*) was set at Z = 2.675. The model was used not only to plug in current values to determine a Z-score, but also to perform stress tests to show what would happen to each component (and its associated weighting) if a financial factor changed.

Another example of LDA is the **RiskCalc© model**, which was developed by Moody's. It incorporates variables that span several areas, such as financial leverage, growth, liquidity, debt coverage, profitability, size, and assets. The model is tailored to individual countries, with the model for a country like Italy driven by the positive impact on credit quality of factors such as higher profitability, higher liquidity, lower financial leverage, strong activity ratios, high growth, and larger company sizes.

With LDA, one of the main goals is to optimize variable coefficients such that Z-scores minimize the inevitable "overlapping zone" between solvent and insolvent firms. For two groups of borrowers with similar Z-scores, the overlapping zone is a risk area where firms may end up incorrectly classified. Historical versions of LDA would sometimes consider a gray area allowing for three Z-score range interpretations to determine who would be granted funding: very safe borrowers, very risky borrowers, and the middle ground of borrowers that merited further investigation. In the current world, LDA incorporates the two additional objectives of measuring default probability and assigning ratings.

The process of fitting empirical data into a statistical model is called **calibration**. LDA calibration involves quantifying the probability of default by using statistical-based outputs of ratings systems and accounting for differences between the default rates of samples and the overall population. This process implies that more work is still needed, even after the scoring function is estimated and Z-scores are obtained, before the model can be used. In the case of the model being used simply to accept or reject credit applications, calibration simply involves adjusting the Z-score cut-off to account for differences between sample and population default rates. In the case of the model being used to categorize borrowers into different ratings classes (thereby assigning default probabilities to borrowers), calibration will include a cut-off adjustment and a potential rescaling of Z-score default quantifications.

Because of the relative infrequency of actual defaults, a more accurate model can be derived by attempting to create more balanced samples with relatively equal (in size) groups of both performing and defaulting firms. However, the risk of equaling the sample group sizes is that the model applied to a real population will tend to overpredict defaults. To protect against this risk, the results obtained from the sample must be calibrated. If the model is only used to classify potential borrowers into performing versus defaulting firms, calibration will only involve adjusting the Z cut-off using Bayes' theorem to equate the frequency of defaulting borrowers per the model to the frequency in the actual population.

Prior probabilities represent the probability of default when there is no collected evidence on the borrower. Prior probabilities q_{insolv} and q_{solv} represent the prior probabilities of insolvency and solvency, respectively. One proposed solution is to adjust the cut-off point by the following relation:

$$\ln\left(\frac{q_{solv}}{q_{insolv}}\right)$$

If it is the case that the prior probabilities are equal (which would occur in a balanced sample), there is no adjustment needed to the cut-off point (i.e., relation is equal to 0). If the population is unbalanced, an adjustment is made by adding an amount from the relation just shown to the original cut-off quantity.

For example, assume a sample exists where the cut-off point is 1.00. Over the last 20 years, the average default rate is 3.75% (i.e., q_{insolv} = 3.75%). This implies that q_{solv} is equal to 96.25%, and the relation will dictate that we must add ln(96.25% / 3.75%) or 3.25 to the cut-off point (1.00 + 3.25 = 4.25).

The risk is the potential misclassification of borrowers leading to unfavorable decisions—rejecting a borrower in spite of them being solvent or accepting a borrower that ends up defaulting. In the case of the first borrower, the cost of the error is an opportunity cost ($COST_{solv/insolv}$). In the case of the second borrower, the cost is the loss given default ($COST_{insolv/solv}$). These costs are not equal, so the correct approach may be to adjust the cut-off point to account for these different costs by adjusting the relation equation as follows:

$$\ln\left(\frac{q_{solv} \times COST_{solv/insolv}}{q_{insolv} \times COST_{insolv/solv}}\right)$$

Extending the earlier example, imagine the current assessment of loss given default is 50% and the opportunity cost is 20%. The cut-off score will require an adjustment of: ln[(96.25% × 20%) / (3.75% × 50%)] = 2.33.

The cut-off point selection is very sensitive to factors such as overall credit portfolio profile, the market risk environment, market trends, funding costs, past performance/budgets, and customer segment competitive positions.

Note that LDA models typically offer only two decisions: accept or reject. Modern internal rating systems, which are based on the concept of default probability, require more options for decisions.

Logistic Regression Models

LO 19.10: Describe the application of logistic regression model to estimate default probability.

Logistic regression models (also known as **LOGIT models**), which are from the Generalized Linear Model (GLM) family, are statistical tools that are also used to predict default. These types of models are based on analyzing the dependencies of one or multiple dependent variables from one or more independent variables. GLMs typically have three common elements:

- A *systematic component*, which specifies the variables used in a linear predictor function.
- A *random component*, which identifies both the target variable and its associated probability function.
- A *link function*, which is a function of the target variable mean that the model ties to the systematic component.

Assume that π represents the probability that a default event takes place. The link function represents the logarithm of the ratio between the default probability and the probability that the firm continues to be a performing borrower (the ratio is known as *odds*). The LOGIT (i.e., logarithm of odds) equation is therefore:

$$\text{LOGIT}(\pi_i) = \log \frac{\pi_i}{1-\pi_i}$$

The LOGIT function associates the expected value for the dependent variable to the *linear* combination of independent variables, whereas the relationship between the probability of default (π) and the independent variables is *nonlinear*.

In the event that there is only one explanatory variable, the LOGIT function becomes:

$$\frac{\pi_i}{1-\pi_i} = e^{(\beta_0+\beta_1 x_{i1})}$$

In this equation, β_1 represents a growth rate such that odds are increased by a factor of e^β for each unit increase in x. Interpreted another way, the odds for x + 1 = the odds for x multiplied by e^β. If $\beta = 0$, $e^\beta = 1$ and the odds will remain the same even if x changes values. e^β can also be thought of as the odds ratio (the ratio of the odds after a unit change in the predictor to the original odds).

Whereas LDA does not yield a sample-based estimate of PD, logistic regression does; however, the probability does require rescaling to the prior probability of the population such that the rescaled default probability π_S is equal to:

$$\pi_S = \frac{\text{ScaledOdds}}{1+\text{ScaledOdds}}$$

A scaled default probability can be created for every possible value coming from a logistic regression. The calibration is complete once each of these default probabilities is assigned to grades in a rating scale.

Sources of information for the independent variables in statistical models include internal behavioral information, external behavioral information (legal disputes, credit bureau reports, dun letters, etc.), financial reports for the individual firm, behavioral data from the credit register, and assessments covering factors such as management quality, competitiveness of the firm, and supplier/customer relationships. Because these sources differ in terms of things like properties, frequency, and data type, models are often specifically built to manage these issues. These individual models (called modules) are then integrated into a final rating model. This serves as a second-level model that uses these inputs to derive a final score.

The individual modules can be connected in a parallel or sequence format. A parallel approach involves the modules' outputs serving as the input for the final second-level model. In the sequential (notching up/down) approach, financial information feeds the model while other modules serve to adjust the results from the financial model up or down.

Cluster Analysis and Principal Component Analysis

LO 19.11: Define and interpret cluster analysis and principal component analysis.

Both LDA and LOGIT methodologies are considered "supervised" due to having a defined dependent variable (the default event), while independent variables are applied to determine an ex ante prediction. When the dependent variable is not explicitly defined, the statistical technique is considered "unsupervised."

Cluster analysis looks to identify groups of similar cases in a data set. Groups represent observation subsets that exhibit homogeneity (i.e., similarities) due to variables' profiles that allow them to be distinguished from those found in other groups. In the context of a database with variables in columns and observations in rows, cluster analysis serves to aggregate borrowers based on the profile of their variables. The end result is a top-down, statistically-based segmentation of borrowers. An empirical default rate can be calculated for each segment, which serves as the default probability for the borrower at each segment. Various other analyses (factor, principal component, and canonical correlation) use columns to optimally transform the variables set into a smaller, statistically more significant set. Two approaches can be used to implement cluster analysis: (1) hierarchical/aggregative clustering and (2) divisive/partitioned clustering.

With **hierarchical clustering**, cluster hierarchies are created and aggregated on a case-by-case basis to form a tree structure with the clusters shown as leaves and the whole population shown as the roots. Clusters are merged together beginning at the leaves, and branches are followed until arriving at the roots. The end result of the analysis typically produces three forms:

- A small number of highly homogeneous, large clusters.
- Some small clusters with comprehensible and well-defined specificities.
- Single, very specific, nonaggregated units.

One of the key benefits of this method is the detection of anomalies. Many borrowers, such as merged (or demerged) companies, start-ups, and companies in liquidation, are unique. This analysis facilitates identifying these unique profiles and managing them separately from other observations.

Divisive clustering begins at the root and splits clusters based on algorithms that assign every observation to the specific cluster whose center (the average of all points in the cluster) is nearest. This approach serves to force the population into fewer cluster groups than what would be found under aggregative clustering. On the other side, high calculation power is needed as expanding the number of observations has an exponential impact.

As an example of applying cluster analysis, we can look to composite measures of profitability such as ROE and ROI. The task is to identify both specific aspects of a firm's financial profile and latent (hidden) variables underlying the ratio system, such that the basic information from a firm's financial statements can be extracted and used for modeling without redundant data and information.

Principal component analysis involves transforming an original tabular data set into a second, derived tabular data set. The performance of a given variable (equal to variance explained divided by total original variance) is referred to as communality, and the higher the communality (the more general the component is), the more relevant its ability to summarize an original set of variables into a new composed variable. The starting point is the extraction of the first component that achieves maximum communality. The second extraction will focus on the residuals not explained by the first component. This process will continue until we have a new principal components set, which will be orthogonal (statistically independent) by design and explain original variance in descending order. In terms of a stopping point, potential thresholds include reaching a minimum predefined variance level or a minimum communality that assures a reasonable level of information using the new set of components.

An *eigenvalue* is a measure of the communality associated with an extracted component. The ideal first component is one that corresponds to the first eigenvalue of the set of variables. The second component will ideally correspond to the first eigenvalue extracted on the residuals. All original variables once standardized contribute a value of one to the final variance. An eigenvalue greater (less) than one implies that this component is summarizing a component of the total variance which exceeds (is less than) the information provided by the original variable. Therefore, it is common that only principal components with eigenvalues greater than one are considered.

For example, a survey of 52 textile firms in Italy was taken in 2007. The results of the extracted principal components are shown in Figure 2.

Figure 2: Principal Components (Italy, Textile Firms in 2007)

Components	*Eigenvalues*	*Explained Variance as % of Total Variance*	*Cumulative Explained Variance*
Component 1	2.76	39.46	39.46
Component 2	1.83	26.10	65.56
Component 3	1.10	15.69	81.25
Component 4	0.83	11.92	93.17
Component 5	0.23	3.23	96.40
Component 6	0.17	2.45	98.85
Component 7	0.08	1.15	100.00
Total	7.00	100.00	

As shown in Figure 2, approximately 81% of the total original variance and associated eigenvalues explain the extent of the variance, which is accounted for in each component. Even though the first variable only accounts for 40%, adding two more gets us to over 80%. In this example, liquidity variables are the first component that does the best job characterizing the data set, as a strong liquidity structure lowers the amount of leverage needed. The second component is profitability, as reduced capital needed for production increases bottom-line profits. The third component focuses on the impacts of intangibles such as R&D investments and market share. The key takeaway from this analysis is that for the Northern Italy Textile sector, a firm's profile is primarily a by-product of these three components (liquidity, profitability, and intangibles). It is also important to take into account correlation coefficients between the original variables and the principal components.

Based on the pattern of these three components, another firm that is part of the population for the sample in Figure 2 could be profiled based on these same fundamental components. Figure 3 illustrates the linkage between the original variables and the first three components.

Figure 3: Linking Variables to Components

Original Variables	*Component 1*	*Component 2*	*Component 3*
ROE (Net Profit / Net Shareholders Capital)	0.13	0.48	0.05
ROI (EBIT / Invested Capital)	0.18	0.44	–0.09
CR (Current Assets / Current Liabilities)	0.32	–0.22	0.05
QR (Liquidity / Current Liabilities)	0.32	–0.17	–0.04
MTCI (Current Liabilities + Permanent Liabilities) / Invested Capital	–0.32	0.08	0.18
SHARE (Market Share) in %	–0.02	0.14	–0.67
R&S (Intangible Fixed Assets / Invested Capital) in %	–0.08	–0.16	–0.65

From this table, a regression analysis equation can be developed for Component 1 as follows:

$$S_1 = \text{ROE}_i \times 0.13 + \text{ROI}_i \times 0.18 + \text{CR}_i \times 0.32 + \text{QR}_i \times 0.32 \\ - \text{MTCI}_i \times 0.32 - \text{SHARE}_i \times 0.02 - \text{R\&S}_i \times 0.08$$

The value derived from this equation is nonstandardized and in the same scale as the original variables, which makes them comparable in terms of mean and variance. Principal component analysis can be used as a way to pre-filter original variables, thereby decreasing their number and eliminating much of the noise of idiosyncratic information.

Factor analysis is similar to principal component analysis, except that factor analysis is used to describe observed variables in terms of fewer unobserved variables called "factors" and can be seen as more efficient. Factor analysis is often used as the second stage of principal component analysis. In terms of the process, step one is to standardize principal

components. Then, the values of the new variables (factor loadings) should be standardized such that the mean equals zero and the standard deviation is equal to one. Even though factor loadings are not comparable (from a size and range perspective) to original variables, they are comparable to each other. Factors will be contingent on the criteria used to conduct what is called the "rotation." The *varimax method* is a rotation method used to target either small or large loadings of a particular variable associated with each factor. As a result of iteratively rotating factor pairs, the resulting solution yields results that make it feasible to identify each variable tied to a single factor. A final solution is reached once the last round provides no added benefit.

The **canonical correlation method** is a technique used to address the correspondence between a set of independent variables and a set of dependent variables. As an example, if an analyst wanted to understand what is explaining the default rate and any changes in default rates over various time horizons, he can look at the relationship between default rate factors and financial ratio factors and understand what common dimensions existed between the tests and the degree of shared variance.

This analysis, which is a type of factor analysis, helps us find linear combinations of the two sets that have a maximum correlation with each other. From this analysis, we can determine how many factors are embedded in the set of dependent variables and what the corresponding factors are out of the independent variables that have maximum correlations with the factors from the dependent variable set. The factors from both sets are independent of one another. Although this method is very powerful, the disadvantages are that it is difficult to rigorously calculate scores for factors, and measuring the borrower profiles can only be done by proxy as opposed to measuring them in new independent and dependent factors.

Cash Flow Simulation Model

LO 19.12: Describe the use of a cash flow simulation model in assigning rating and default probability, and explain the limitations of the model.

A **cash flow simulation model** is most often used to assign ratings to companies that have non-existent or relatively meaningless track records. In an ideal situation, a given firm's future cash flow simulation will stay in the middle between structural and reduced form models. The simulation will be based on forecasting a firm's pro forma financial reports and studying the volatility of future performances. The assumed measure of default probability can be based on the number of future scenarios where a default event occurs versus the total number of simulated scenarios. Structural approaches and reduced form approaches are brought together in different models and solutions.

One of the biggest risks of cash flow simulation models is *model risk*, which stems from the fact that any model serves as a simplified version of reality. Defining default for the purposes of the model is also challenging, as it cannot always be known if and when a default will actually be filed in real-life circumstances. Therefore, the default threshold needs to be set such that it is not too early (the risk of having too many defaults, resulting in transactions that are deemed risky when they are not truly risky) and not too late (the risk of having not enough defaults, thereby understating the potential risk). Costs must also be taken into account, as models can cost a lot of money to build, maintain, and calibrate.

Even given these issues, there are not many feasible alternatives to using the simulation model for a firm in certain conditions when historical data cannot be observed. For firms such as project companies, special-purpose entities, leveraged buyouts, or recently merged companies, any existing covenants and negative pledges are specifically signed for the purpose of mitigating risky events. These clauses must be incorporated and assessed to understand when they will be triggered and the extent of their effectiveness.

Ratings (and associated default probabilities) are assigned using cash flow simulation models. The models will take into account the amount of cash flows generated by operations, the amount that will be used for any financial obligations and other investments, and related determinants such as technology, demand, and costs. The models will also take into account future pro forma specifications. Either a numerical simulation model or a scenario approach can be used to determine the probability of default. For a numerical simulation, a large number of model iterations can be used which would describe different scenarios; stages such as default, no-default, near-to-default, or stressed can then be determined, and then the frequency of different stages can be computed. For a scenario approach, probabilities can be applied to discrete predefined scenarios. Ratings can be determined using weighted averages of future outcomes.

Heuristic Approaches vs. Numerical Approaches

LO 19.13: Describe the application of heuristic approaches, numeric approaches, and artificial neural network in modeling default risk and define their strengths and weaknesses.

Through the application of artificial intelligence methods, other techniques have been applied to predicting default in recent years. These two primary approaches include:

- **Heuristic methods**. These methods are designed to mirror human decision-making processes and procedures. Trial by error is used to generate new knowledge rather than using statistical modeling. These methods are also known as “expert systems,” with a goal of reproducing high frequency standardized decisions at the highest level of quality at a low cost. The fundamental idea is to learn from both successes and errors.
- **Numerical methods**. The objective of these methods is to derive optimal solutions using “trained” algorithms and incorporate decisions based on relatively weak information in very complex environments. An example of this is a “neural network,” which is able to continuously update itself in order to incorporate modifications to the environment.

An **expert system**, which is a traditional application of artificial intelligence, is a set of software solutions designed to produce answers to problems where human experts would otherwise be needed. Expert systems will typically involve the creation of a knowledge base and will use knowledge engineering to gather and codify knowledge into a framework. The typical components of an expert system include the working memory (short-term memory), the user interface/communication, the knowledge base (long-term memory), and the inferential engine (the heart/nervous network). Production rules are developed by knowledge engineers and are then used to create an environment that mirrors approaches for human problem solving.

The rule base of an expert system consists of many inference rules (which are designed to resemble human behavior); these go into the knowledge base as separate rules, and the

inference engine serves to bring them together to draw conclusions. The inference engine can use either backward chaining or forward chaining. With *backward chaining* (goal driven), the starting point is a list of goals. Working backward, the expert system will look to find paths that will allow it to achieve these goals. Rules are searched until one is found which best aligns to the desired goal. With *forward chaining* (data driven), the starting point is available data. Inference rules are applied until a desired goal is achieved. Once the path is recognized as successful, it is applied to the data.

An expert system may also incorporate "fuzzy logic" applications. This logic applies "rules of thumb" based on feelings and uses approximate as opposed to precise reasoning. A fuzzy logic variable will not be confined to the extremes of zero and one; rather, they can assume any value that exists between the two extreme values. Fuzzy logic will ultimately widen the rules spectrum that can be used by expert systems, which allows them to better approximate human decision processes. On occasion, an expert system may also be used when there are new conditions that haven't been experienced previously (such as new procedures, new markets, etc.). A subset of expert systems is *decision support systems* (DSSs), which are applied to certain phases of the human decision-making process and involve very complex and cumbersome calculations.

Neural networks come from biological studies and serve to simulate human brain behavior. These networks involve the interconnection of artificial neurons (software programs designed to mirror the properties of biological neurons) and have the ability to continuously learn by experience. They are used primarily when data is rough, unreliable, mistaken, or even partially missed. They are also useful when decisions come from fuzzy environments and from environments where negotiations are needed or when market conditions change rapidly.

In a neural network, weights (defined as "potential" or "intensity" of a specific neuron) are multiplied by the input data, with the sum of the products influenced by a flexible mathematical function and the specific calculation path involving some but not all nodes. The network derives the signals gathered and applies a weighting to the inputs at every node. A neuron is considered active if it generates an input to other nodes, and it is ignored if it does not. Interactions between neurons can be considered strong or weak connections, with the connections based on weights and paths that inputs travel through before getting to the specific neuron.

One of the key benefits of the neural network method is its ability to capture nonlinear relationships. Because a network may have thousands of nodes and even more potential connections, the flexibility exists to handle highly complex, nonlinear, recursive, and independent problems. The most common structure is the "hierarchically dependent neural network."

In the specific area of credit risk, "supervised learning" is the most applied method. In this method, a training set is given and the network learns how to obtain a successful result by finding the structure of the nodes and determining the optimal path to achieve the best final result. A cost function is also set to define outcome utility. So to model default risk, borrower characteristics are used to form the training set while misclassification costs are set using the cost function.

In terms of limitations, there is no way to look step-by-step at neural networks to determine how results are obtained; we have to accept that the results will come from what appears like a "black box," which makes it impossible to explain how and why we arrived at a specific result. A way around this issue is to prepare multiple data sets characterized by distinguishing profiles and then put them in the neural network to obtain results. With outputs coming from homogeneous inputs, it is possible to then deduce the critical variables and their associated weights. Also, these networks are highly sensitive to the quality of the inputs; as such, data sets must be carefully chosen to not have the model learn from outliers. In addition, continuous quantitative variables are more appropriate for neural networks than qualitative variables.

Over-fitting is a major risk for estimating neural networks, as a network that over-fits a sample of data will not be able to produce quality results when applied to other samples, such as sectors, borrowers, economic cycle stages, and geographic areas.

An expert system is advantageous when human experts have known, clear, and well-dominated experience; this experience allows for the formalization of rules and building of effective systems. Expert systems provide structure and order to real-life procedures, which facilitate the replication of decision-making processes with robust quality and high frequency. Expert systems are also useful in connecting different stages of a decision-making process to one another. For the purposes of rating assignments, expert systems provide objectivity, order, and discipline to the ratings process; however, they do not provide new knowledge because they are not inferential methods or models.

Numerical approaches, like neural networks, provide classifications, often with low granularity (like very good, pass, reject, etc.). These models are not statistical models and, therefore, do not produce outputs like probabilities of default. This limitation, along with the "black box" limitation described earlier, limits the usefulness of neural networks outside of segments such as personal loans or consumer credit. However, they can be used for potential early warnings and credit quality monitoring. Also, a neural network is very useful for processing extremely large quantities of data, adjusting quickly when a discontinuity occurs, and creating new rules when a change in the pattern of success/failure is uncovered.

Comparing heuristic approaches (i.e., expert systems and decision support systems) to numerical approaches (i.e., neural networks) across the three key features of a good ratings system discussed earlier shows the following results:

- *Objectivity and Homogeneity*. Both are almost entirely compliant.
- *Specificity*. The numerical approach is 75% compliant, while the heuristic approach is 50% compliant.
- *Measurability and Verifiability*. The numerical approach is 75% compliant, while the heuristic approach is 50% compliant.

Applying Qualitative Information

LO 19.14: Describe the role and management of qualitative information in assessing probability of default.

Although statistical methods are ideal for managing quantitative data, qualitative type information is extremely relevant to modeling default risk and must be captured. From the perspective of using judgment to ultimately determine credit approval, three categories are used to encapsulate qualitative information:

- Investment, innovation, and technology.
- Human resource management, motivation, retention of key resources, and maximizing talent.
- Effective and efficient internal processes.

The following list represents examples of qualitative type information that must be accounted for in some capacity in default analysis:

- Primary customers and suppliers (concentration and quality).
- Range of products and services, both domestic and abroad.
- Commercial network, global presence, and diversification.
- Quality, competence, and experience of management.
- In-progress investments.
- Prior experiences with nonrecurring events such as foreclosures, credit losses, payment delays, and government support.
- Usage of new and innovative technologies in payment systems, as well as integrations with accounting, managerial information, and administration systems.
- Financial reporting quality, systems, internal controls, internal reporting, audit functions, and overall transparency.
- Financial relationships.
- Resource allocations, internal organization, and management among multiple branches.
- Group structure and organization.
- Compliance and conformity with environmental concerns and social responsibilities.
- Corporate governance and checks and balances.

The types of qualitative items that may be found in a credit analysis questionnaire include things like corporate structure (incorporation date, group members), business information (competitive forces within the industry, growth forecasts), management quality (degree of involvement, experience), strategy (business plans, nonrecurring transactions such as mergers and transfers), financial position sustainability (liquidity risk, debt maturity concentration), quality of information given to the bank by the company (availability of financial projections, relationship history), and other risks (geographic focus, client base quality). Due to the enormous breadth of qualitative factors, a best practice would be to only collect qualitative information that cannot be quantified.

Categorical types of information include binary information (such as yes/no), nominal information (like locations of incorporation), and ordinal classifications with graduating levels (such as low, medium, and high). Binary information can be represented as dummy variables (i.e., 0 or 1). Ordinal information can be assigned numbers and weights differing at each level. Even with these options for quantification, the lack of historical data is a major problem with using qualitative information.

A potential mechanism for overcoming these issues is to invoke a two-stage process:

- *Stage 1*: Build a quantitative model along with launching a systematic qualitative data collection on new reports.
- *Stage 2*: Once Stage 1 has produced enough information, build a new model which includes the new qualitative information.

In spite of the challenges of incorporating qualitative data, this data set is a critical element to building powerful credit models and driving long-term value creation for banks.

Key Concepts

LO 19.1

Ratings are used as a means for banks and other lenders to manage credit risk. To be effective, a good rating system will have three key features:

1. Objectivity and homogeneity, meaning it will produce judgments tied solely to credit risk and ratings that are comparable across market segments, portfolios, and customer types.

2. Specificity, meaning it accurately captures the distance to default while ignoring other non-default-related financial elements.

3. Measurability and verifiability, meaning it will provide accurate expectations tied to default probabilities backtested on a continuous basis.

LO 19.2

Experts-based approaches (such as those that incorporate the four Cs of credit) rely on experienced individuals who can provide valuable inputs into the models. Statistical-based models use both quantitative and qualitative data to describe the real world in a controlled environment. Numerical-based models are designed to derive optimal solutions using trained algorithms.

LO 19.3

A rating migration matrix is used to show the relative frequencies with which counterparties move from one rating class to another. Migrations tend to be correlated and dependent, such that when initial ratings are high (low), they become worse (better) than expected. Key measures to assess default risk include the probability of default, the cumulative probability of default, the marginal probability of default, and the annualized default rate.

LO 19.4

The three main international ratings agencies are Moody's (provides ratings for issuances), Fitch (provides issuer ratings for public bonds), and Standard & Poor's (provides ratings for issuers).

Standard & Poor's process for assigning a rating includes the following chronological steps: (1) receiving an issuer request, (2) following up with an initial evaluation, (3) meeting with management, (4) analysis, (5) a review and vote by the rating committee, (6) a notification to the issuer, (7) the dissemination of ratings opinions, and (8) continued monitoring. Final ratings come from the primary areas of financial risk and business risk, along with factoring in sovereign risk, the competitive environment for the issuer, and business sector strength.

LO 19.5

Given the law of large numbers and homogeneous populations, default probabilities can be used to estimate future population behavior. The higher (lower) the rating is for the issuer, the lower (higher) the probability of default. Over a period of time, such as 10 years, the highest-rated issuers will practically never default, while the lowest-rated issuers often default early and are almost assured of default over that same time frame.

LO 19.6

The processes used by a rating agency to assign ratings will differ from the internal methods used by banks, even with similar underlying processes. In terms of the three features of a good ratings system, agencies' ratings are considered more compliant than internal experts-based ratings for objectivity and homogeneity (75% versus 50%), specificity (100% versus 75%), and measurability and verifiability (75% versus 25%).

LO 19.7

The structural approach to predicting default involves building a model that estimates the formal relationships linking relevant model variables. The reduced form approach (which is heavily dependent on the samples chosen) achieves a final solution using the most statistically suitable variables without accounting for their relationships. Within the category of reduced form approaches, there are statistical-based models and numerical-based models.

LO 19.8

The Merton model is a structural approach based on the premise that default occurs when a company's proprietary structure is no longer deemed worthwhile. The default probability and the distance to default can be calculated using relevant financial variables, such as interest rates, maturity, debt face value, the underlying value of the asset, and the asset's volatility. The model is highly sensitive to market movements and variables, such as asset value, volatility, and the underlying debt itself, which are difficult and complicated to value.

LO 19.9

Linear discriminant analysis (LDA) is a reduced form method used to develop scoring models and to provide accept/reject decisions. An LDA produces a scoring function, which is a linear function of variables, such as accounting ratios whose contributions to the overall score are represented by a Z-score. A Z cut-off is used to differentiate firms that are solvent from those that are insolvent, although there is an "overlapping zone" that can lead to misclassifications. Adjustments can be made to the cut-off score for unbalanced populations and the costs of misclassifications.

LO 19.10

Logistic regression (LOGIT) models are tools used to predict default based on understanding the relationships between dependent and independent variables. The output of these models is a sample-based estimate of the probability of default. The probability output must be scaled, and the model must be calibrated. The individual models developed (i.e., modules) are integrated using either a parallel or sequence approach into a final rating model.

LO 19.11

Cluster analysis serves to identify groups of similar cases into unique data sets, effectively aggregating and segmenting borrowers based on the profiles of their variables. From here, a default rate can be calculated for each segment as a proxy for their default probability. Principal component analysis takes original tabular data and transforms it into a new derived data set which is used to determine the primary drivers of a firm's profile and potential default. Factor analysis is often used as the second stage of principal component analysis.

LO 19.12

Cash flow analysis is useful for assigning ratings to companies that don't have meaningful historical data for predicting potential default. Ratings and default probabilities are assigned using these models, which account for operational cash flows, cash used for investments and obligations, and other cash-related determinants. Challenges to the model include model risk (oversimplifying reality), costs for building and maintaining the model, and accurately defining default.

LO 19.13

Heuristic methods (known as expert systems) are designed to predict default by mirroring human decision-making processes and procedures. Numerical methods predict default using trained algorithms and apply decisions based on weak information in complex environments. Artificial neural networks are examples of numerical methods that are able to continuously learn by experience.

LO 19.14

Qualitative information is very relevant for modeling default risk. This type of information centers on areas such as corporate structure, business information, management quality, strategy, financial position sustainability, communication of information, and risks. Capturing historical data for qualitative information is particularly challenging, as is placing a reasonable scope around the breadth and quantity of factors that must be analyzed.

Concept Checkers

1. Which of the following statements is most accurate in regard to describing a good rating system?
   A. A specific rating system accurately measures the distance from a default event.
   B. A verifiable rating system requires backtesting default probabilities on at least a monthly basis.
   C. A homogeneous rating system provides judgments based solely on credit risk considerations.
   D. An objective rating system results in ratings that can be compared across customer types and market segments.

2. As shown in the Moody's migration matrix (Figure 1 on page 40), the only rating class where an issuance has a greater than 50% chance of changing from its initial to final rating class is:
   A. Aaa.
   B. Baa.
   C. Caa.
   D. Ca-C.

3. In comparing agency rating systems to internal (experts-based) rating systems, evidence has shown that:
   A. internal systems and agency systems are equally compliant in regard to specificity.
   B. agency systems are more compliant in regard to verifiability than internal systems.
   C. agency systems are less compliant in regard to measurability than internal systems.
   D. internal systems are more compliant in regard to objectivity and homogeneity than agency systems.

4. A credit analyst is using linear discriminant analysis (LDA) to determine a Z-score cut-off for differentiating default from solvency. Assume that the current cut-off point is 1.00, the average default rate is 2.75%, the current assessment of loss given default is 45%, and the opportunity cost is 15%. What is the new cut-off score after the Z-score cut-off adjustment?
   A. 2.47.
   B. 3.47.
   C. 4.66.
   D. 5.66.

5. Each of the following items represents an example of qualitative information that would ideally be captured in assessing default probability except:
   A. management's education and experience.
   B. internal controls associated with financial reporting.
   C. diversification of products and customers locally and globally.
   D. trends in throughput and other operational efficiency metrics.

Concept Checker Answers

1. **A** In order for a rating system to meet the specificity requirement, it must measure the distance to a default event. A verifiable rating system requires backtesting on a continuous basis. A homogeneous rating system implies that ratings are comparable among customer types, market segments, and portfolios. An objective rating system produces judgments based on considerations tied to credit risk.

2. **D** For issuances with initial ratings of Ca-C, there is only a 38.7% chance that their final ratings will remain Ca-C. For all other ratings classes, there is a greater than 50% chance that their initial ratings will equal their final ratings.

3. **B** Across all features of a good rating system (objectivity and homogeneity, specificity, and measurability and verifiability), agency ratings are deemed more compliant than internal, experts-based rating systems.

4. **B** The cut-off score will require an adjustment of: $\ln[(97.25\% \times 15\%) / (2.75\% \times 45\%)] = 2.47$. By adding this adjustment to the original cut-off point of 1.00, the new cut-off score will be equal to 3.47.

5. **D** Trends and other efficiency measures that can be captured with metrics are considered quantifiable, which means they are not considered qualitative measures. The other three items are considered qualitative in that they are not easily and consistently quantified.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Credit Risks and Credit Derivatives

Topic 20

Exam Focus

The potential failure of a party to fulfill an agreed-upon payment is an uncertainty for risk managers. The pricing of risky debt using the Merton model provides insight into predicting the probability of default and the amount of loss should default occur. Additional approaches have been developed to evaluate the credit risk of portfolios and provide estimates of a portfolio's credit value at risk. Credit derivatives provide the risk manager with financial instruments that are used to hedge credit risk exposures. This topic presents several models for evaluating and measuring credit risk, along with examples of credit derivatives used to hedge credit risk exposure. For the exam, be sure to understand the calculation of firm equity and debt under the Merton model.

Credit risk refers to the chance that a party will fail to make promised payments. Risk managers assess credit risk and determine its potential impact on income and if it should be hedged using derivatives contracts or some other means.

The two important roles that credit risk plays in risk management programs are (1) assessing the potential of default by debt claimants and (2) assessing the potential of default by counterparties of derivatives contacts.

Derivative contracts with payoffs dependent on a specified credit event are called **credit derivatives.** Risk managers use credit derivatives to hedge their exposure to credit risk.

The Merton Model

LO 20.1: Using the Merton model, calculate the value of a firm's debt and equity and the volatility of firm value.

The Merton model, based on Black-Scholes-Merton option pricing theory, evaluates various components of firm value. The simplest form of the model assumes the existence of a non-dividend paying firm with only one liability claim and that financial markets are perfect. That is, the model assumes away taxes, bankruptcy costs, and costs associated with enforcing contracts.

Suppose that the firm's only debt issue is a zero-coupon bond with a face value (or principal amount) of F, due at the maturity date of T. If the firm is unable to pay the principal at T, then the firm is bankrupt and the equity claimants receive nothing. Alternatively, if the firm value at T, V_T, is large enough to pay the principal amount, then equity holders have claim to the balance, $V_T - F$. These two payoff possibilities are the same as the payoffs for a call

option, with the firm value as the underlying asset and the principal amount as the exercise price. Therefore, the value of equity at *T* is:

$$S_T = \text{Max}(V_T - F, 0)$$

Example: Computing the value of equity

Calculate the value of the firm's equity at T, S_T, given that principal amount due on the zero-coupon bond is $50 million and the total value of the firm at T, V_T, is $60 million. In addition, what is the value of equity if V_T is $40 million?

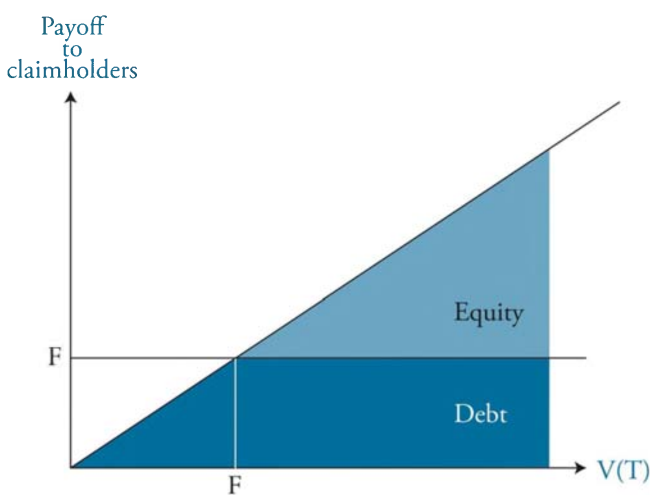
Answer:

$$S_T = \text{Max}(60 - 50, 0) = 10 = \$10 \text{ million}$$

$$S_T = \text{Max}(40 - 50, 0) = 0 = \$0 \text{ million}$$

Figure 1 depicts the payoffs at *T* of the claimholders relative to the total firm value. The shape of the payoff for equity is the same as the payoff of a long call option. The payoff for debt is similar to that of a risk-free bond and a short position in a put option, but the uncertainty of the payoff requires some additional analysis.

Figure 1: Debt and Equity Payoffs When Debt is Risky



If the debtholder knew with certainty that he would receive the principal amount at the maturity for the zero-coupon bond, then the payoff would be *F* regardless of the firm value. However, the debtholder cannot expect to receive *F* if the total value of the firm, V_T, is less than *F*. Therefore, if $F > V_T$ then the amount received by the debtholder will be reduced by

$F - V_T$. This payoff is the same as buying a Treasury bill with a face value of *F* and selling a put on the firm value with an exercise price of *F*. Therefore, the value of debt at *T* is:

$$D_T = F - \text{Max}(F - V_T, 0)$$

Example: Computing the value of debt

Calculate the value of the firm's debt at *T*, D_T, given that principal amount due on the zero-coupon bond is \$50 million and the total value of the firm at *T*, V_T, is \$40 million. In addition, what is the value of debt if V_T is \$60 million?

Answer:

$$D_T = 50 - \text{Max}(50 - 40, 0) = 50 - 10 = 40 = \$40 \text{ million}$$

$$D_T = 50 - \text{Max}(50 - 60, 0) = 50 - 0 = 50 = \$50 \text{ million}$$

Since we know that the value of the debt plus the value of equity must be equal to the total value of the firm, alternative valuation formulas can be developed. For example, since the value of the firm at *T* is:

$V_T = D_T + S_T$ then the value of debt at *T* can also be written as:

$D_T = V_T - S_T$ and by substitution:

$$D_T = V_T - \text{Max}(V_T - F, 0)$$

Therefore, the value of debt is also the difference between the value of the firm and the call option on the value of the firm with *F* as the exercise price.

The Black-Scholes-Merton option-pricing model for European options can be modified to determine the value of equity prior to *T*, *T* – *t*, if additional assumptions are made, which include:

- Firm value characterized by a lognormal distribution with constant volatility, σ.
- Constant interest rate, *r*.
- Perfect financial market with continuous trading.

The Value of Equity at Time *t*

Using arbitrage pricing for a portfolio of securities that replicates the value of the firm results in Merton's formula for the value of equity such that:

$$S_t = V \times N(d) - Fe^{-r(T-t)} \times N(d - \sigma\sqrt{T-t})$$

where:

$$d = \frac{\ln\left(\frac{V}{Fe^{-r(T-t)}}\right)}{\sigma\sqrt{T-t}} + \frac{1}{2}\sigma\sqrt{T-t}$$

V = value of the firm
F = face value of the firm's zero-coupon debt maturing at *T* (only liability)
σ = volatility of the value of the firm
r = annual interest rate
N(d) = cumulative normal distribution function evaluated at *d*

Example: Compute the value of equity

Using the Merton model, **calculate** the value of the firm's equity at *t* given that the current value of the firm is $60 million, the principal amount due in 3 years on the zero-coupon bond is $50 million, the annual interest rate, *r*, is 5%, and the volatility on the firm, σ, is 10%.

Answer:

$$S_t = 60 \times N(d) - 50e^{-0.05(3)} \times N(d - \sigma\sqrt{T-t})$$

$$d = \frac{\ln\left(\frac{60}{(50)(0.8607)}\right)}{(0.10)\sqrt{3-0}} + \frac{1}{2}(0.10)\sqrt{3-0} = \frac{\ln(1.3942)}{0.1732} + \frac{1}{2}(0.1732) = 2.005$$

$$S_t = 60 \times N(2.005) - 50 \times 0.8607 \times N(2.005 - 0.1732)$$

Professor's Note: N(d) can be found in a table of probability values (the z-table in the appendix).

$$S_t = 60 \times 0.9775 - 43.035 \times 0.9665 = 58.650 - 41.593 = 17.057$$

Therefore, the value of equity of the firm is $17.057 million.

The Value of Debt at Time *t*

There are two methods for valuing risky debt in this framework. Risky debt is equal to:

- Risk-free debt minus a put option on the firm.
- Firm value minus equity value.

Example: Compute the value of debt

Calculate the current value of the firm's debt as a portfolio of risk-free debt and a short position in a put on firm value with an exercise price of the face value of debt. Assume that the current value of the firm is \$60 million, the principal amount due in three years on the zero-coupon bond is \$50 million, the annual interest rate is 5%, and the volatility on the firm, σ, is 10%. Recall from the previous example that the value of equity is \$17.057 million.

Answer:

$$D_t = Fe^{-r(T-t)} - p_t$$

$$D_t = 50 \times e^{(-0.05)(3)} - p_t$$

$$D_t = 50 \times 0.8607 - p_t$$

$$D_t = 43.035 - p_t$$

Using put-call parity, the value of the put is:

$$p_t = c_t + Fe^{-r(T-t)} - V$$

$$p_t = c_t + 43.035 - 60$$

$$p_t = 17.057 + 43.035 - 60 = 0.092$$

$$D_t = 43.035 - p_t = 43.035 - 0.092 = 42.943$$

Therefore, the value of the debt issue is \$42.943 million.

Example: Compute the value of debt

Calculate the current value of the firm's debt as the difference between the total firm value and the value of equity priced as a call option. Assume that the current value of the firm is $60 million, the principal amount due in three years on the zero-coupon bond is $50 million, the annual interest rate is 5%, and the volatility on the firm, σ, is 10%.

Answer:

$$D_t = V - S_t$$

$$D_t = 60 - 17.057 = 42.943$$

Again, the value of debt is $42.943 million.

Figure 2 shows the general relationships between debt and equity values according to the inputs of the Merton model.

Figure 2: Relationships Between Debt and Equity Values as Compared to the Inputs of the Merton Model

	Value of Firm, V	*Face Value of Debt, F*	*Time to Maturity, T*	*Interest Rate, r*	*Volatility of the Firm, σ*
Value of debt	+	+	–	–	–
Value of equity	+	–	+	+	+

Credit Spreads, Time to Maturity, and Interest Rates

LO 20.2: Explain the relationship between credit spreads, time to maturity, and interest rates, and calculate credit spread.

A **credit spread** is the difference between the yield on a risky bond (e.g., corporate bond) and the yield on a risk-free bond (e.g., T-bond) given that the two instruments have the same maturity. For example, if a corporate bond is yielding 7% and the yield on the T-bond with the same maturity is 5%, the credit spread would be equal to 2%. This spread indicates that a higher yield is received for taking on increased risk.

The credit spread can be calculated using the following formula:

$$\text{credit spread} = -\left[\frac{1}{(T-t)}\right] \times \ln\left(\frac{D}{F}\right) - R_F$$

where:
$(T - t)$ = remaining maturity
D = current value of debt
F = face value of debt
R_F = risk-free rate

For a given risky bond, the most you can receive is the par value at maturity. However, as time increases there is greater probability that the value received will be less than par. Studies have shown that as time to maturity increases, credit spreads tend to widen (i.e., increase). This applies to both high-rated and low-rated debt. However, for very risky debt, it may be the case that credit spreads narrow since there is a greater chance of payment as maturity approaches.

In addition to time to maturity, interest rates can also impact credit spreads. As the risk-free rate increases, the expected value of the firm at maturity increases, which in turn decreases the risk of default. A reduction in the risk of default will narrow (i.e., decrease) credit spreads.

Example: Calculating credit spread

Assume that the face value on a firm's zero-coupon debt with five years remaining to maturity is equal to $100 million. Also assume that the current value of this debt is $77 million. **Compute** the credit spread for this scenario if the risk-free rate (implied by the zero-coupon bond price) is 4%.

Answer:

$$\text{credit spread} = -\left(\frac{1}{5}\right) \times \ln\left(\frac{77}{100}\right) - 0.04 = -(0.2 \times -0.261) - 0.04 = 0.0122 = 1.22\%$$

Determining Firm Value and Volatility

Since there is no single claim for the value of a levered firm, the value of the firm is unobservable. Further, it is virtually impossible to directly trade the value of the firm. These deficiencies can be solved using the Merton model if we assume that small changes in the return on equity are perfectly correlated with the value of the firm.

A portfolio consisting of a call option on the firm and a risk-free asset is equivalent to the value of the firm. Thus, a small change in firm value will change the value of equity by delta, Δ, times the change in firm value. Delta is the rate of change in the value of the call option relative to the change in the value of the underlying asset, $\Delta S/\Delta V$. The Merton model delta, Δ, is equal to $N(d)$. Therefore, if we know the parameters for calculating the value of equity as a call and the value of risk-free debt, then we can determine the firm's value and the volatility of firm value.

Figure 3: Low Firm Values and High Firm Values Using the Merton Model

	Low Firm Values			*High Firm Values*		
Value of firm per share	2.50	3.00	3.60	25.00	30.00	36.00
Value of equity per share, S_t	0.196	0.306	0.469	15.659	20.164	25.723
Change in value of equity if value of firm increases by 20%	---	56.1%	53.3%	---	28.8%	27.6%
Delta	0.197	0.245	0.299	0.886	0.914	0.937

Although delta is increasing as the value of the firm increases, the change in the value of equity decreases as firm value increases. This indicates that the distribution of equity values is not constant (which is sometimes referred to as a volatility smirk). The non-constant volatility of equity is a violation of the Black-Scholes-Merton model.

The **Geske compound option model** is appropriate for valuing the equity call option because it assumes that the value of the firm is characterized by a lognormal distribution with a constant variance.

If we know the value of equity and the value of an option on firm equity, we can use an iterative process to solve for firm value and firm volatility. A value for firm volatility and firm value is selected, and a value for equity is estimated using the Black-Scholes-Merton model. The same values for firm volatility and firm value are used in the compound option model to arrive at a value for the call option on equity. The outputs of the two models are then compared to actual values of equity and equity call option. Adjustments are made to firm value and firm volatility until the outputs of both models are the same as the actual values.

For example, suppose that the value of the firm is selected to be \$25 per share, the volatility, σ, is 50%, the value of the call option using the compound option model is \$6.0349 and the value of equity from the Merton model is \$15.50. Also suppose the actual call option price is \$6.72 and the actual equity price is \$14.10.

Since the value of the option of \$6.0349 is below \$6.72 and the value of equity per share is above the observed price per share of \$14.10, the firm value is too high and the volatility of the firm is too low. To decrease the value of equity from the Merton model, the value of the firm should be lower. To increase the value of the call option using the compound option model, the volatility measure needs to be higher. The results of the iterative process indicates that a firm value of \$21 per share and a firm volatility of 68.36% produces model values that are equal to the observed values.

Subordinate Debt

LO 20.3: Explain the differences between valuing senior and subordinated debt using a contingent claim approach.

LO 20.4: Explain, from a contingent claim perspective, the impact of stochastic interest rates on the valuation of risky bonds, equity, and the risk of default.

In the event of bankruptcy, subordinate debt will receive payment only after all obligations to senior debt have been paid. Because of the uncertainty associated with financial distress, the value of subordinate debt acts more like an equity security than a debt security. Therefore, when a firm is in financial distress, the value of subordinate debt will increase as firm volatility increases, while the value of senior debt will decline.

Suppose a firm has one issue of subordinate debt (SD) and one issue of senior debt (D) where both issues have the same maturity date, T. F and U represent the face values of senior debt and subordinate debt, respectively. Equity, S, is valued as a call option on the value of the firm, V, with an exercise price of F + U.

Subordinate debt can be valued in a portfolio as a long position in a call option on the firm with an exercise price equal to the face value of senior debt, F, and a short position on a call option on the firm with an exercise price equal to the total principal due on all debt, U + F. Figure 4 illustrates the portfolio payoffs for the previous equations.

Figure 4: Subordinated Debt Payoff

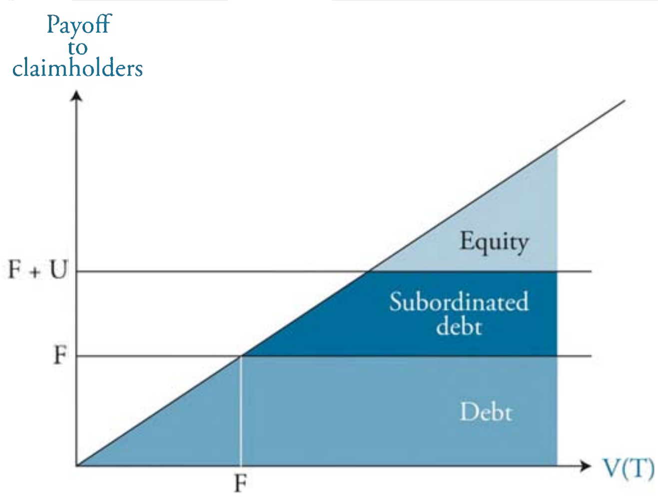


Figure 5 illustrates how subordinate debt values behave like equity when the firm has low values, as during periods of financial distress, and how they behave like senior debt when the firm is not in financial distress.

Figure 5: Relationships for Capital Components for Low vs. High Firm Values

	If Firm Value is Low Firm in Financial Distress			*If Firm Value is High Firm Not in Financial Distress*		
Variable	*Time to Maturity T*	*Firm Volatility σ*	*Annual Interest Rate r*	*Time to Maturity T*	*Firm Volatility σ*	*Annual Interest Rate r*
Senior debt	–	–	–	–	–	–
Subordinate debt	+	+	+	–	–	–
Equity	+	+	+	+	+	+

Interest Rate Dynamics

In the absence of credit risk, unanticipated changes in interest rates can affect the value of debt and the value of the firm. Increases in interest rates will decrease the value of debt because of pricing sensitivities of debt. Empirical evidence indicates that, on average, firm stock prices decline as interest rates rise. Therefore, to hedge debt, we need to account for the interactions between changing interest rates and firm value.

The Vasicek model allows for interest rates to revert to a long-run mean. The change in interest rates in the Vasicek model at time t is:

$$\Delta r_t = k(\theta - r_t)\Delta t + \sigma_r \varepsilon_t$$

where:
k = speed that interest rate reverts to the long-run mean, θ
r_t = current interest rate
σ_r = interest rate volatility
ε_t = random error term

To value debt, Shimko, Tejima, and Van Deventer (1993)[1] developed a variation of the Merton model that included the correlation between firm value and changes in interest rates, $\rho_{(V,\Delta r)}$.

Figure 6 illustrates the relationships between interest rate dynamics of a low value firm (i.e., firm in financial distress) and the value of debt.

Figure 6: Interest Rate Dynamics of Firm in Financial Distress

	$\rho_{(V,\Delta r)}$	k	σ_r	T
Value of debt	–	–	–	–

The sensitivity of the value of debt to changes in interest rates is dependent on the volatility of interest rates. When interest rate volatility is high the debt values are less sensitive to changes in interest rates. Therefore, hedging against the adverse affect of changing interest rates is dependent on the parameters of the dynamic interest rate model.

1. Shimko, David C., Naohiko Tejima, and Donald R. Van Deventer, 1993, "The Pricing of Risky Debt When Interest Rates Are Stochastic," *Journal of Fixed Income*, 3(2), 58–66.

Application Difficulties

Application of the Merton model is complicated by the complexity of firms' capital structures. Most firms have a variety of debt instruments that mature at different times and have many different coupon rates (i.e., not just zero-coupons). In addition to the many different types of debt issues, the Merton model does not allow the firm value to jump. Since most defaults are surprises, the inability to have jumps in the firm value in the Merton model makes default too predictable.

Empirical research confirms the predictability of the Merton model. Jones, Mason, and Rosenfeld (1984)[2] report that a naïve model of predicting whether debt is riskless works better for investment grade bonds than the Merton model. However, the Merton model works better than the naïve model for debt below investment grade. Kim, Ramaswamy, and Sundaresan (1993)[3] report the Merton model's inability to predict credit spreads. The documented problems with the Merton model created the need for models to predict default more accurately (such as the KMV approach).

Using the Merton Model to Calculate PD and LGD

The simplest case for calculating probability of default assumes that the process for default is not correlated with the interest rate process or the recovery rate. The recovery rate is a fixed proportion of the principal that the debtholder receives in the event of default. The recovery rate is not dependent on time.

To find the value of debt, the probability of default and the recovery rate are required. If the debt is publicly traded, then the probability of default and the recovery rate can be estimated from the current price of debt; however, most debt instruments are not publicly traded.

In addition to the lack of public trading, there are four differences in measuring the risk of a debt portfolio that make estimating the probability of default and the loss due to default more challenging:

- If securities are illiquid, then the historical data is not reliable.
- The distribution of bond returns is not normal because the debtholder cannot receive more than the face amount plus the sum of the coupons.
- Debt is issued by creditors who do not have traded equity.
- Debt is not marked to market in contrast to traded securities. That is, a loss is recognized only if default occurs.

2. Jones, Philip E., Scott P. Mason, and Eric Rosenfeld, 1984, "Contingent Claims Analysis of Corporate Capital Structures: An Empirical Investigation," *Journal of Finance*, 39(3), 611–625.
3. Kim, In Joon, Krishna Ramaswamy, and Suresh Sundaresan, 1993, "Does Default Risk in Coupons Affect the Valuation of Corporate Bonds?—A Contingent Claims Model," *Financial Management*, 22, 117–131.

The Merton model for probability of default (PD) and loss given default (LGD) assumes that firm value is lognormally distributed with a constant volatility, and that the firm only has one liability, which is zero-coupon debt issue. The model also requires the expected return on the value of the firm, μ. The Merton model for PD is:

$$PD = N\left(\frac{\ln(F) - \ln(V) - (\mu)(T-t) + 0.5\sigma^2(T-t)}{(\sigma)\sqrt{T-t}}\right)$$

where:
N = cumulative normal distribution
F = face value of the zero-coupon bond
V = value of the firm
T = maturity date on bond
σ = volatility of firm value

Loss given default (LGD) is:

$$LGD = F \times (PD) - Ve^{\mu(T-t)} \times N\left(\frac{\ln(F) - \ln(V) - \mu(T-t) - 0.5\sigma^2(T-t)}{\sigma\sqrt{T-t}}\right)$$

Example: Compute PD and LGD

Suppose a firm with a value of $60 million has a bond outstanding with a face value of $50 million that matures in three years. The current interest rate is 6% and the volatility of the firm is 25%. What is the probability that the firm will default on its debt if the expected return on the firm, μ, is 15%? What is the expected loss given default?

Answer:

$$PD = N\left(\frac{\ln(50) - \ln(60) - (0.15)(3) + (0.5)(0.25)^2(3)}{(0.25)\sqrt{3}}\right) = N(-1.244) = 0.1069 = 10.69\%$$

$$LGD = 50(0.1069) - 60e^{0.15(3)}N\left(\frac{\ln(50) - \ln(60) - 0.15(3) - 0.5(0.25)^2(3)}{0.25\sqrt{3}}\right)$$

$$LGD = 5.345 - (94.099)N(-1.677) = 5.345 - (94.099)(0.0468) = 5.345 - 4.404$$
$$= 0.941 = \$941{,}000$$

Figure 7 illustrates the relationships between the inputs of the Merton model and the probability of default and then compares each relationship to loss given default.

Figure 7: Relationships for PD and LGD Relative to Variables in the Merton Model

	Value of Firm	*Firm Value Volatility, σ*	*Expected Return, μ*	*Time to Maturity, T*	*Face Value of Debt, F*
Probability of default, PD	–	+	–	–	+
Loss given default, LGD	–	+	–	–	+

Credit Risk Portfolio Models

LO 20.5: Compare and contrast different approaches to credit risk modeling, such as those related to the Merton model, CreditRisk+, CreditMetrics, and the KMV model.

Portfolio credit risk models resolve some of the difficulties of measuring a portfolio's probability of default and the amount of loss associated with default when using the Merton model. The models also allow for the inclusion of additional securities and contracts, such as swaps. Therefore, instead of having only debtholders in the model, the model includes other obligors. Obligors include all parties who have a legal obligation to the firm.

Using various methodologies, credit risk portfolio models attempt to estimate a portfolio's credit value at risk. Credit VaR (also called **credit at risk** or **default VaR**) is defined much the same as VaR (a.k.a. market VaR); the minimum credit loss at a given significance over a given time period (or alternatively, the maximum credit loss for a given confidence level over a given time period).

Credit VaR differs from market VaR in that it measures losses that are due specifically to default risk and credit deterioration risk. Like market VaR, credit VaR is measured over a specified time period at a specified probability. There are two problems, however, when calculating credit VaR. First, calculating changes in credit quality over a 1-day period is difficult. Therefore, credit VaR is usually calculated over a year, where the potential change in credit risk is more easily estimated. The second problem is that changes in credit risk are highly skewed and do not follow a normal distribution. The loss distribution of changes in credit quality for investment grade bonds closely resembles a lognormal distribution.

CreditRisk+

CreditRisk+ measures the credit risk of a portfolio using a set of common risk factors for each obligor. Each obligor has its own sensitivity to each of the common risk factors. The model allows for only two outcomes (default or nondefault) for a loss of a fixed size. The probability of default for each obligor is dependent on the credit rating and the obligor's sensitivity to each of the risk factors. Conditional on the risk factors, the model assumes that defaults are uncorrelated across obligors.

Risk factors can only have positive values and are scaled to have a mean of one. The risk factors are assumed to follow a specific distribution, such as a gamma distribution. If an obligor has a risk factor greater than one, then the probability of default for firm i increases in proportion to the obligor's exposure. After the probability of default for each obligor is calculated, the loss distribution for the portfolio can be estimated and used to assess the credit risk of the portfolio.

CreditMetrics

CreditMetrics is used for determining the credit value at risk (VaR) for large portfolios of debt claims.

Steps in calculating credit VaR using CreditMetrics:

Step 1: Determine rating class for debt claim.
Step 2: Use historical rating transition matrix to determine the probability that claim will migrate.
Step 3: Estimate the distribution of value for claim by computing the expected values for one year.
Step 4: Use the 1-year forward zero curves rates to get current price of zero-coupon bond for one year.
Step 5: Assume annual coupons to compute value of bond for each possible rating for next year.
Step 6: Compute the expected bond value $E(BV_p) = \sum_{i=1}^{N} p_i BV_i$. Then compute the credit value at risk (VaR) for a given confidence level.

where:
p = probability of migrating from a given rating
BV = the bond value plus coupon for a given rating

Example: Compute VaR using CreditMetrics[4]

Suppose your portfolio contains a senior unsecured bond issued by Triple-Bee, Inc. The bond with a credit rating of BBB matures in five years and pays a 6% coupon. If the recovery rate is 51.13%, what is the 1% credit VaR, given the following 1-year forward zero rates for the next four years and the 1-year transition probabilities of a bond with a BBB rating? Assume the bond's market price is $106.

Figure 8: One-Year Forward Zero Curves Rate for Each Rating Class (%)

Rating Class	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Bond Value Plus Coupon for Next Year*
AAA	3.60	4.17	4.73	5.12	109.37
AA	3.65	4.22	4.78	5.17	109.19
A	3.72	4.32	4.93	5.32	108.66
BBB	4.10	4.67	5.25	5.63	107.55
BB	5.55	6.02	6.78	7.27	102.02
B	6.05	7.02	8.03	8.52	98.10
C	15.05	15.02	14.03	13.52	83.64

The bond value for next year is calculated by discounting the coupons and the principal amount by the appropriate forward rate. For example, the bond value for the BB rating class is calculated as:

$$6+\frac{6}{(1+0.0555)^1}+\frac{6}{(1+0.0602)^2}+\frac{6}{(1+0.0678)^3}+\frac{6+100}{(1+0.0727)^4}=102.02$$

Figure 9: Estimation of Mean Bond Value Given the One-Year Probabilities of Migration from BBB and the Recovery Rate of 51.13% for the Triple-Bee Bond

Year-End Rating Class	*Probability of Migrating from BBB (%)*	*Cumulative Probability (%)*	*Bond Value Plus Coupon*	*(Probability) × (Bond Value Plus Coupon)*
AAA	0.02	100.00	109.37	0.022
AA	0.33	99.98	109.19	0.360
A	5.95	99.65	108.66	6.465
BBB	86.93	93.70	107.55	93.493
BB	5.30	6.77	102.02	5.407
B	1.17	1.47	98.10	1.148
C	0.12	0.30	83.64	0.100
Default	0.18	0.18	51.13	0.092
Expected bond value $E(BV_p)=\sum_{i=1}^{N} p_i BV_i$				107.087

4. The data on which this example is based can be found in the CreditMetrics® Technical Manual, available on the RiskMetrics® website at www.riskmetrics.com.

Answer:

The cumulative probability column in Figure 9 estimates the first percentile. The expected bond value of 98.10 is at 1.47% in the cumulative distribution and is used as a proxy for the first percentile. Since credit VaR is the difference between the current bond price and the first percentile, the credit VaR for a bond with a current price of 106 is estimated to be \$7.90 (= 106 – 98.10).

Correlations are important in a portfolio. If two bonds are independent, then the probability of both bonds migrating is the product of the individual events. If the bonds are not independent, then we need to know the migration correlations. The major complexity of CreditMetrics is estimating the joint migration of bonds in a portfolio. If the historical estimates for joint probabilities are used, then additional information is required. However, if stock returns are used to estimate the correlations between bond issues, the problem is solved. CreditMetrics recommends using a factor model where stock returns depend on country and industry indices as well as unsystematic risk.

Moody's KMV Portfolio Manager

Previously, we discussed the KMV approach for estimating expected default probabilities. That approach is known as Moody's KMV Credit Monitor™. Another KMV model that is based on the Merton model, but is specifically designed for managing credit risk in a portfolio setting, is known as Moody's KMV Portfolio Manager™. KMV Credit Monitor provides data for Portfolio Manager.

The KMV model, a modified Merton model, calculates the **expected default frequencies** (EDFs) for each obligor. This modified model allows for more complicated capital structures (e.g., short-term debt, long-term debt, convertible debt, and equity). KMV solves for firm value and volatility.

The primary advantage of the KMV model is the use of current equity values in the model. This allows for the impact of a current event to immediately affect the probability of default. Ratings changes occur with a considerable lag. The use of equity values allows for probabilities of default to change continuously as equity values change. In the CreditMetrics approach, the value of the firm can change without any impact on the probability of default.

The KMV model computes the expected return from a variation of the capital asset pricing model (CAPM), which uses a factor model to simplify the correlation structure of firm returns. This provides for a direct estimation of the loss distribution without requiring the use of simulation to estimate the credit VaR of the credit portfolio.

CreditPortfolioView

CreditPortfolioView models the transition matrices using macroeconomic or economic cycle data. This is its primary distinguishing feature. Macroeconomic variables are the key drivers of default rates, and CreditPortfolioView estimates an econometric model for an index that drives the default rates of an industrial sector. The model simulates paths of the index, which produces a distribution of portfolio losses to analyze. Usually the focus is on an aggregate default rate for an entire economy.

The user can select the inputs for the econometric model. Examples of often-used inputs are GDP growth, interest rates, and unemployment. In the United States and other countries, this data is readily available from public sources. The default rates per industry and country may not always be readily available in other countries, so proxies must be used.

The procedure can be summarized in four steps:

1. Measuring the autoregressive process of the macroeconomic variables.
2. Composing sector indices for the variables.
3. Estimating a default rate based on the value of that index.
4. Comparing the simulated values to historical values to determine the transition matrix to use.

The second and third parts of the procedure consist of simulating future possible realizations of the indices and then using an appropriate transformation (e.g., logistic transformation) on the simulations so they become a distribution of default rates. If the simulations indicate that the probability of default is above (below) the historical average, the user would conclude that the sector is in recession (expansion), and they would choose a recession (expansion) transition matrix.

Limitations of the Credit Portfolio Models

Credit portfolio models have made improvements at estimating the probability of default; however, most models do not account for changes in:

- Interest rates.
- Credit spreads.
- Current economic conditions.

The state of the economy does affect probability of default for bonds. As the economy moves from an expansionary period to a recessionary period the distribution of defaults changes. In 1991 defaults were at a peak and then declined through the 1990s as the economy expanded. The correlations increase during a recession. Credit risk models that use historical correlations are not able to account for changing economic conditions.

Credit Derivatives

LO 20.6: Assess the credit risks of derivatives.

LO 20.7: Describe a credit derivative, credit default swap, and total return swap.

A credit derivative is a contract with payoffs contingent on a specified credit event.

Credit derivatives are designed as hedging instruments for credit risks. Credit derivatives are usually traded over the counter (OTC) and not on exchanges.

Credit events include:

- Bankruptcy.
- Failure to pay.
- Restructuring.
- Repudiation.
- Moratorium.
- Obligation acceleration.
- Obligation default.

One of the simplest credit derivatives is a credit default put. A **credit default put** pays on a loss of debt due to default at the maturity of the debt claim, *T*.

Example: Computing the payoffs from a credit default put

Suppose a fixed income portfolio manager buys a bond issue with a face amount of $100 million that matures in one year. The payoff of the risky bond is the same as a portfolio of owning a 1-year Treasury bill and a short position in a put written on the bond issuer's firm value with the exercise price equal to the face value of debt. To hedge the credit risk that the issuer of the debt will not pay the full amount, the debtholder can buy a credit default put on the value of the firm with an exercise price equal to the debt's face value. What is the payoff of holding a risky bond hedge with a credit default put, if the value of the risky firm's value is $60 million?

Answer:

Figure 10: Payoffs of Risky Bond Hedged With a Credit Default Put

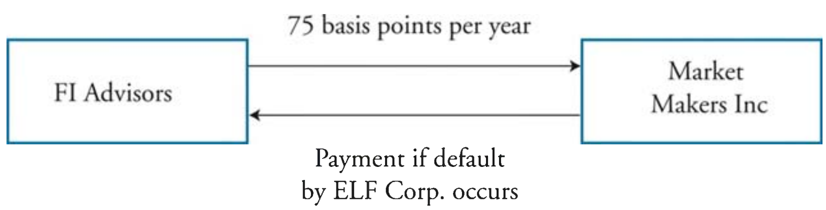
Value of the firm, *V*	60
Payoff of risk-free bond, *F*	100
Short position in put –Max(F–V,0)	–40
Risky debt is a risk-free bond + short put	60
Credit default put Max(F–V,0)	40
Hedged payoff	100

A more complex and popular credit derivative is the **credit default swap** (CDS). A CDS is similar to a typical swap in that one party makes payments to another party. The purchaser of the CDS seeks credit protection and will make fixed payments to the seller of the CDS for the life of the swap, or until a credit event occurs. This differs from a typical interest rate swap where net payments are based on some fixed and floating rates of interest. The underlying "reference" in a CDS is whether a credit event takes place. If a credit event takes place, the buyer of the CDS will make a final "accrual" payment based on the amount of time elapsed since last payment. Then the swap is settled in either physical delivery of the reference obligation, or in cash.

If the terms of the swap agreement dictate settlement by physical delivery, the buyer of the CDS delivers the reference obligation to the seller of the swap and receives the par value. If the terms of the swap agreement are for cash delivery, dealers are surveyed a specified number of days following a credit event to determine a midpoint between bid and ask prices, called *Z*, which will then be used to calculate the cash payment as (100 – Z)% of the notional principal.

Suppose FI Advisors owns fixed income securities issued by ELF Corp. (the reference entity issued the reference obligation) with a par value of $200 million. FI Advisors would like to protect its position against credit risk by using a credit-default swap and is able to purchase this credit protection in a credit-default swap from Market Makers, Inc., for 75 basis points of a notional principal determined to be $200 million. The life of the CDS is five years, which will require FI Advisors to pay $1.5 million to Market Makers, Inc., every year. If ELF Corp. does not default, FI Advisors receives nothing from this agreement. If ELF Corp. does default, however, Market Makers, Inc., pays FI Advisors the notional principal of $200 million. The general CDS transaction can be seen in Figure 11.

Figure 11: Example of Credit Default Swap



Total rate of return swaps (TROR) are agreements to exchange the total return of a reference asset (i.e., a risky corporate bond) for a floating rate (LIBOR) plus a specified spread. The total return of the reference asset will include both capital gains (or losses) and any flows (coupons, interest, dividends) over the life of the swap.

The total-return payer payments would be similar to those of an investment in the underlying security in exchange for LIBOR plus the spread. If the payer owns the reference asset, a total return swap would allow the owner to transfer the credit risk of the asset to the receiver. If the payer does not own the reference asset, a total return swap's cash flows would be similar to those of taking a short position in the bond. If the value of the bond declines, the payer position gains. If the value of the bond increases, the payer position loses.

Conversely, the cash flows to the receiver can be viewed as the total return on the reference asset, which is a floating rate obligation. Although the payer counterparty retains ownership of the asset, the receiver is exposed to the capital gains (or losses) and the credit risk of the

asset. The spread above the floating rate the receiver is obligated to pay will depend on the credit risk of the reference asset, the creditworthiness of the receiver, and the correlation of credit quality between the reference asset issuer and the total return swap receiver.

Derivatives With Credit Risks

A **vulnerable option** is an option with default risk. An option holder receives the promised payment only if the seller of the option is able to make the payment. Without the default risk, the holder of the option at expiration receives:

$$\text{Max}(S - X, 0)$$

where:
S = underlying asset's price at expiration
X = exercise price

The vulnerable option holder receives the promised payment only if the value of the counterparty firm, *V*, is greater than the required payment on the option. The payoff of the vulnerable option is:

$$\text{Max}[\text{Min}(V, S - X), 0]$$

The correlation between the value of the firm and the underlying asset value, $\rho_{(V,S)}$, is important in the valuations of the vulnerable option. If $\rho_{(V,S)}$ is strongly negative then vulnerable option has little value because firm value is low when vulnerable option payoff is to occur. If $\rho_{(V,S)}$ is strongly positive then there is no credit risk because firm value is high when the value of equity is high.

If the option has credit risk, then a derivative contract can be written to eliminate the credit risk. If the price of the vulnerable option can be estimated then the price of the credit derivative to insure the vulnerable option can be determined. The payoff of the option used to hedge the credit risk of a vulnerable option is:

$$\text{Max}(S - X, 0) - \text{Max}[\text{Min}(V, S - X), 0]$$

An alternative approach computes the probability of default and a recovery rate estimate if default occurs. The value of the option is the weighted average of the option without default. Following this approach, the value of a vulnerable option is:

$$\text{vulnerable option} = [(1 - PD) \times c] + (PD \times RR \times c)$$

where:
c = value of the option without default
PD = probability of default
RR = recovery rate

Example: Compute the value of a vulnerable option

Suppose a firm has a debt issue with a probability of default of 10% and a recovery rate of 40%. What is the value of the vulnerable option?

Answer:

Vulnerable option value = $(1 - 0.1)c + (0.1)(0.4)c = 0.90c + 0.04c = 0.94c$; therefore, the vulnerable option is worth 94% of the value of the option that is free of default risk.

LO 20.8: Explain how to account for credit risk exposure in valuing a swap.

The credit risk in a swap can be reduced by requiring a margin or by netting the payments. Netting is a method where the payments are offset so that only one party needs to make a payment. The covenants of the swap agreement can affect the credit risk exposure. Suppose a counterparty that is due to receive a net payment is in default. If the swap agreement has a *full two-way payment covenant*, then the counterparty still receives the net payment. However, if the swap has a *limited two-way payment covenant*, the obligations are abolished if either party is in default. Valuing a swap can be simplified by considering a swap with only one payment.

Suppose there is only one payment to be made in a swap arrangement between Market Maker, Inc. and Risky Credit, Inc., which has no liabilities at the creation of the swap. The agreement provides for Risky Credit to receive a fixed amount, F, at maturity and to pay a variable amount, S, based on some index. The index could be based on an equity value or a floating rate. If the payments are netted, Market Maker will receive the difference between the variable payment and the fixed payment $(S - F)$, assuming there is no default risk such that Market Maker's payoffs are:

If $S < F$ then Market Maker pays $F - S$

If $S > F$ then Market Maker receives $S - F$

If Risky Credit's ability to pay is uncertain (subject to default risk), then the payment to be received from Risky Credit is the smaller of $(S - F)$ or the firm value of Risky Credit, V.

When we consider the default risk of Risky Credit, the swap's payoff to Market Maker is:

$$(-)\text{Max}(F - S, 0) + \text{Max}[\text{Min}(S, V) - F, 0]$$

For Market Maker, the risk-free counterparty, the payoff of the swap is the same as a portfolio of a short position on a put option and a long position on a call. The put is written on an asset with a value of S and an exercise price of F. The call option is written on the lower of the variable payment, S, or the value of the risky counterparty, V, with the exercise price of the fixed payment, F. At the initiation of the swap agreement, F is selected so that the swap has no value.

The correlation between firm value, V, and the variable payment, S, is critical to the valuation of the swap. If the correlation declines, then there is no effect on the value of the put option, but the value of the option on the two risky assets declines.

Key Concepts

LO 20.1

Credit risk is the chance that a party will fail to make promised payments. The two important roles that credit risk plays in risk management programs are (1) assessing the potential of default by debt claimants and (2) assessing the potential of default by counterparties of derivatives contacts.

Given the assumptions of the Merton model, a levered firm's equity can be valued as a call option written on the value of the firm with the face value of debt as the exercise price and the time to the debt's maturity as the time to expiration. The value of equity is an increasing function of firm value, time to maturity of debt, interest rates, and volatility of the firm and a decreasing function of the face value of debt.

The value of debt, in the Merton model, is the difference between the firm value and the call option written on the value of the levered firm. The value of debt is an increasing function of firm value and the face value of debt and a decreasing function of the time to maturity of debt, interest rates, and the volatility of firm value.

LO 20.2

A credit spread is the difference between the yield on a risky bond the yield on a risk-free bond given that the two instruments have the same maturity. As time to maturity increases, credit spreads tend to widen. A reduction in the risk of default will narrow credit spreads.

LO 20.3

An extension of the Merton model provides for the pricing of subordinate debt. When a firm is experiencing financial distress (low firm values), the behavior of the values of subordinate debt are more similar to that of equity. However, if a firm is not experiencing financial distress (high firm values), the behavior of the values of subordinate debt resembles senior debt.

LO 20.4

The sensitivity of the value of debt to changes in interest rates is dependent on the volatility of interest rates. When interest rate volatility is high, the debt values are less sensitive to changes in interest rates.

LO 20.5

Credit risk models have made improvements at estimating the probability of default. CreditRisk+ measures the credit risk of a portfolio conditional on a set of common risk factors for each obligor. CreditMetrics measures the credit VAR for the portfolio. The KMV model, a modified Merton model, calculates the expected default frequencies (EDFs) for each obligor.

LO 20.6

A credit derivative is a derivatives contract with payoffs contingent on a specified credit event. Credit events include the following: failure to make required payments, restructuring that harms the creditor, invocation of cross-default clause, and bankruptcy.

LO 20.7

A credit default put is a credit derivative that pays on a loss of debt due to default at the maturity of the debt claim.

In a credit default swap (CDS), the party with the credit exposure from a debt claim will make fixed payments to a counterparty. The counterparty then agrees to pay the shortfall if the obligor is not able to meet the requirements of the debt contract (i.e., credit event). A credit event triggers the payment by the counterparty.

A total return swap involves swapping the total return from a debt obligation in exchange for a specified payment. The lending party who wants to hedge its credit risk exposure agrees to pay the interest payments and any decline in the market value of the debt instrument and receives a risk-free variable rate payment (usually based on LIBOR).

LO 20.8

In a risky swap agreement, the correlation between a risky counterparty's firm value and the variable payment, is critical to the valuation of the swap. If the correlation declines, then there is no effect on the value of the put option, but the value of the option on the two risky assets declines.

Concept Checkers

1. A corporate bond with a face value of $1,000 has a remaining maturity of 15 years. Using the Merton model, the current value of the bond is calculated at $650. Assuming that the risk-free rate is equal to 2%, what is the credit spread for this bond?
   A. 23 bps.
   B. 65 bps.
   C. 87 bps.
   D. 98 bps.

2. A non-dividend paying firm financed with 100% equity issues a zero-coupon bond with a principal amount of $50 million due in three years. What are the values of the different components of the firm's capital structure at the maturity date of the bond if the firm value at that time is $40 million?
   A. $50 million in debt and $10 million in equity.
   B. $10 million in debt and $30 million in equity.
   C. $50 million in debt and $40 million in equity.
   D. $40 million in debt and $0 in equity.

3. Suppose a firm has two debt issues outstanding. One is a senior debt issue that matures in three years with a principal amount of $100 million. The other is a subordinate debt issue that also matures in three years with a principal amount of $50 million. The annual interest rate is 5% and the volatility of the firm value is estimated to be 15%. If the volatility of the firm value declines in the Merton model, then which of the following statements is true?
   A. If the firm is experiencing financial distress (low firm value), then the value of senior debt will increase while the values of subordinate debt and equity will both decline.
   B. If the firm is not experiencing financial distress (high firm value), then the value of senior debt and subordinate debt and equity will increase.
   C. If the firm is experiencing financial distress (low firm value), then the value of senior debt and subordinate debt will increase while equity values will decline.
   D. If the firm is not experiencing financial distress (high firm value), then the value of senior debt will increase while the values of subordinate debt and equity will both decline.

4. Which of the following statements regarding the Merton model is true?
   A. A firm with numerous debt issues that mature at different times is easy to value with the Merton model.
   B. The Merton model assumes a lognormal distribution and constant variance for changes in firm value.
   C. The Merton model is able to predict default because it allows for default surprises (i.e., jumps).
   D. Empirical results indicate that the Merton model is able to predict default better than naïve models for investment grade bonds.

5. Which of the following is a characteristic of the KMV model?

   I. Each obligor has its own sensitivity to each of the common risk factors.
   II. It includes an estimate of correlation between firm values based on the correlation between observed equity values.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

Concept Checker Answers

1. **C** The credit spread is calculated using the following formula:

$$\text{credit spread} = -\left[\frac{1}{(T-t)}\right] \times \ln\left(\frac{D}{F}\right) - R_F$$

$$= -\left(\frac{1}{15}\right) \times \ln\left(\frac{650}{1000}\right) - 0.02 = 0.0087 = 87\,\text{bps}$$

2. **D** The value of equity is the value of a call on the value of the firm with an exercise price equal to the face value of the zero-coupon bond, $S_T = \text{Max}(V_T - F, 0) = \text{Max}(40 - 50, 0) = 0$ (i.e., equity has no value). The value of debt is $D_T = F - \text{Max}(F - V_T, 0)$ or alternatively, $D_T = V_T - S_T$. Therefore, the value of debt is 40 – 0 = 40 = $40 million.

3. **A** When firms with subordinate debt are experiencing financial distress (low firm values), changes in the value of subordinate will react to changes in the model parameters in the same way as equity. Since equity is valued as a call option in the Merton model, a decline in volatility will reduce the value of equity (and subordinate debt). When firms with subordinate debt are not experiencing financial distress (high firm values), changes in the value of subordinate will react to changes in the model parameters in the same way as senior debt. Since senior debt is valued as the difference in firm value less equity valued as a call option in the Merton model, a decline in volatility will increase the value of senior debt (and subordinate debt).

4. **B** Most firms have a variety of debt instruments that mature at different times and have many different coupon rates (i.e., not just zero-coupons as assumed by the Merton model); therefore, Choice A is false. The Merton model assumes that the underlying asset follows a lognormal distribution with constant variance; therefore, Choice B is true. The Merton model does not allow the firm value to jump. Since most defaults are surprises, the inability to have jumps in the firm value in the Merton model makes default too predictable; therefore, Choice C is false. Jones, Mason, Rosenfeld (1984) report that a naïve model of predicting that debt is riskless works better for investment grade bonds than the Merton model. However, the Merton model works better than the naïve model for debt below investment grade; therefore, Choice D is false.

5. **B** Statement I is only true for CreditRisk+. Statement II is a characteristic and major advantage of the KMV model.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Spread Risk and Default Intensity Models

Topic 21

Exam Focus

Investors require a return for bearing credit risk, which is typically expressed relative to risk-free rates (e.g., yield spread, OAS, CDS spread). Default can be modeled with simple Bernoulli trials or more complicated intensity (hazard) models. For the exam, know the relationship between hazard rates, cumulative default probability, and conditional default probability. Also know that the credit spread is approximately equal to loss given default times probability of default.

Spread Conventions

LO 21.1: Compare the different ways of representing credit spreads.

LO 21.2: Compute one credit spread given others when possible.

Informally, a credit spread represents the difference in yields between the security of interest (e.g., corporate bond) and a reference security (typically a higher rated instrument). Ideally, these two securities would have the same maturity, so the difference in yields represents the difference in risk premiums, not compensation for the time value of money. As intuitive and attractive as this definition is, unfortunately, it can be interpreted in many different ways. Figure 1 summarizes various spread measures.

Figure 1: Various Spread Measures

Spread Measure	*Definition*
Yield spread	YTM risky bond – YTM benchmark government bond
i-spread	YTM risky bond – linearly interpolated YTM on benchmark government bond
z-spread	Basis points added to each spot rate on a benchmark curve
Asset-swap spread	Spread on floating leg of asset swap on a bond
CDS spread	Market premium of CDS of issuer bond
Option adjusted spread (OAS)	*z*-spread adjusted for optionality of embedded options. *z*-spread = OAS if no option
Discount margin	Fixed spread above current LIBOR needed to price bond correctly

The more common spread definitions (yield spread, i-spread, and *z*-spread) are demonstrated in the following examples.

Example 1: Assume the following information regarding XYZ Company and US Treasury yields.

	XYZ	*US Treasury*
Coupon rate	6% semi-annual coupon	4% semi-annual coupon
Time to maturity	20 years (7.25% YTM)	20 years (4.0% YTM)
Yield curve		4.0% flat

Based on this information, yield spread = 7.25% – 4% = 3.25% (325 basis points)

Example 2: Assume the following information regarding XYZ Company and US Treasury yields.

	XYZ	*US Treasury*
Coupon rate	6% semi-annual coupon	4% semi-annual coupon
Time to maturity	19 years (7.25% YTM)	20 years (4.0% YTM) 18 years (3.6% YTM)
Yield curve		4.0% flat

Because the maturity of the XYZ bond does not match exactly with the maturity of the quoted Treasury bonds, the i-spread will be computed as:

i-spread = 7.25% – (4.0% + 3.6%) / 2 = 3.45%

Example 3: For this example, we consider the calculation of the *z*-spread in a continuous time framework. XYZ bond is trading at a 6% discount (94% of par) with an 8% semi-annual coupon and 10 years to maturity. Assume a flat swap curve at 10% and a spot rate of 9.6% compounded continuously for all maturities. The *z*-spread is calculated using the following expression:

$$0.94 = \left(\frac{0.08}{2}\right)\sum_{i=1}^{10\times 2} e^{-(0.096+z)0.5} + e^{-(0.096+z)10}$$

Spread '01

LO 21.3: Define and compute the Spread '01.

Recall the concept of DV01, the dollar value of a basis point, from the FRM Part I curriculum. DV01 captures the dollar price change from a one basis point change in the current yield. A similar concept for credit spreads is known as DVCS (i.e., spread '01). Here, the potential change in the bond price is estimated from a one basis point change in the *z*-spread. Specifically, the *z*-spread is shocked 0.5 basis points up and 0.5 basis points down and the difference is computed.

For example, if the current *z*-spread is 207 bps and the bond is priced at \$92, we could consider incremental 0.5 basis point changes to compute the spread '01. When the *z*-spread is increased by 0.5 basis points to 207.5 bps, the new bond price is \$91.93 and when the *z*-spread tightens by 0.5 basis points to 206.5 bps, the bond price increases to \$92.14. Hence, given a \$100 par value, the spread '01 is: 92.14 – 91.93 = 0.21 dollars per basis point.

We can further study the comparative statistics of this result. Intuitively, the smaller the *z*-spread, the larger the effect on the bond price (i.e., the greater the credit spread sensitivity). This result is straightforward because the same one basis point change represents a larger shock relative to the current *z*-spread when the *z*-spread is low. Thus, the DVCS exhibits convexity.

Binomial Distribution

LO 21.4: Explain how default risk for a single company can be modeled as a Bernoulli trial.

A Bernoulli trial is an experiment or process where the outcome can take on only two values: success or failure (i.e., a binomial distribution). Success and failure are relative terms that denote that either the event happens ("success") or does not happen ("failure"). The obvious connection to our discussion is that a firm does or does not default during a particular time period. Let us define the relevant time period as $T_2 - T_1 = \tau$ where the firm will default with probability π and remains solvent with probability $1 - \pi$. The mean and variance of a Bernoulli distribution is equal to π and $\pi(1 - \pi)$, respectively.

An important property of the Bernoulli distribution is that each trial is conditionally independent. That is, the probability of default in the next period is independent of default in any previous period. Hence, if a firm has survived until the current period, the probability of default in the next period is the same as in its first year of existence. This memoryless property is exactly the same as studying a series of coin flips. For example, if you observed that a fair coin has landed on heads 10 consecutive flips, then the best guess for another heads on the 11th flip is still 50%.

Do not confuse this concept with the cumulative probability of default. Consider a firm with probability π of default each period. The likelihood of surviving the next eight periods is $(1 - \pi)^8$. We can clearly see that as long as a firm has a positive probability of default, it will eventually default in a sufficiently long period of time.

Exponential Distribution

LO 21.5: Explain the relationship between exponential and Poisson distributions.

The exponential distribution is often used to model waiting times such as how long it takes an employee to serve a customer or the time it takes a company to default. The probability density function for this distribution is as follows:

$$f(x) = \frac{1}{\beta} \times e^{-x/\beta}, x \geq 0$$

In this function, the scale parameter, β, is greater than zero and is the reciprocal of the "rate" parameter λ (i.e., $\lambda = 1 / \beta$). The rate parameter measures the rate at which it will take an event to occur. In the context of waiting for a company to default, the rate parameter is known as the **hazard rate** and indicates the rate at which default will arrive.

As mentioned, the exponential distribution is able to assess the time it takes a company to default. However, what if we want to evaluate the total number of defaults over a specific time period? As it turns out, the number of defaults up to a certain time period, N_t, follows a Poisson distribution with a rate parameter equal to t / β.

A **Poisson random variable** X refers to the *number of successes per unit*, the parameter lambda (λ) refers to the average or *expected number of successes per unit*. The mathematical expression for the Poisson distribution for obtaining X successes, given that λ successes are expected, is:

$$P(X = x) = \frac{\lambda^x e^{-\lambda}}{x!}$$

We can further examine the relationship between the exponential and Poisson distributions by considering the mean and variance of both distributions. The mean and variance of a Poisson distributed random variable is equal to λ and, as it turns out, the mean of the exponential distribution is equal to $1 / \lambda$ and the variance is equal to $1 / \lambda^2$.

Hazard Rates

LO 21.6: Define the hazard rate and use it to define probability functions for default time and conditional default probabilities.

LO 21.7: Calculate the conditional default probability given the hazard rate.

The hazard rate (i.e., default intensity) is represented by the (constant) parameter λ and the probability of default over the next, small time interval, *dt*, is λdt. Stated differently, the probability of default over $(t, t + dt) = \lambda dt$. It follows naturally that the probability of survival over the same time interval *dt* is $1 - \lambda dt$.

If the time of the default event is denoted t*, the cumulative default time distribution $F(t)$ represents the probability of default over (0, t):

$$P(t^* < t) = F(t) = 1 - e^{-\lambda t}$$

Professor's Note: This equation calculates the cumulative probability of default (cumulative PD), which is an unconditional default probability.

Similarly, the survival distribution is $P(t^* \geq t) = 1 - F(t) = e^{-\lambda t}$ and both survival and default probabilities sum to 1 at each point in time. In other words, if you have not defaulted by time *t*, then you have survived until this point. As *t* increases, the cumulative default probability approaches 1 and the survival probability approaches 0.

For completeness, we provide the marginal default probability (or default time density) function as the derivative of $F(t)$ with respect to the variable *t*:

$$\lambda e^{-\lambda t}$$

It is evident that this quantity is always positive indicating that the probability of default increases over time related to the intensity parameter λ.

Previously, the exponential function was used to model the default probability over (0, t). If we examine the probability of default over $(t, t + \tau)$ given survival up to time *t*, the function is a conditional default probability. The instantaneous conditional default probability (for small τ) is equal to $\lambda\tau$.

The conditional one-year probability of default, assuming survival during the first year, is equal to the difference between the unconditional two-year PD and the unconditional one-year PD, divided by the one-year survival probability. The following example demonstrates this calculation.

Example: Computing default probabilities

Given a hazard rate of 0.15, **compute** the one-, two-, and three-year cumulative default probabilities and conditional default probabilities.

Answer:

t	*Cumulative PD*	*Survival Probability*	*PD(t, t+1)*	*Conditional PD Given Survival Until Time t*
1	$1 - e^{-0.15(1)} =$ 0.1393	1 – 0.1393 = 0.8607	0.1393	
2	$1 - e^{-0.15(2)} =$ 0.2592	1 – 0.2592 = 0.7408	0.2592 – 0.1393 = 0.1199	0.1199 / 0.8607 = 0.1393
3	$1 - e^{-0.15(3)} =$ 0.3624	1 – 0.3624 = 0.6376	0.3624 – 0.2592 = 0.1032	0.1032 / 0.7408 = 0.1393

Notice that the conditional probabilities in the far right column are constant.

Risk-Neutral Hazard Rates

LO 21.8: Calculate risk-neutral default rates from spreads.

In structural models, such as the Merton model, the default probabilities are based on specific pricing functions associated with the firm's assets and liabilities (in essence, structural models implicitly assume the modeler has as much information about the firm as the firm's managers). On the other hand, reduced form models will take the market price of liquid securities such as a credit default swap (CDS) as fairly priced and back out the market's aggregated expectations of default. To calculate risk-neutral default rates from spreads we are interested in working with reduced form models, which start with market observable spreads.

Let's start by comparing zero-coupon corporate bonds to maturity-matched default-free government bonds. Since the only cash flows occur at maturity, the current prices differ based on their yields. Specifically, the price of a default-free bond maturing in τ is:

$$p_\tau = e^{-r_\tau \tau}$$

where:
r_τ = continuous discount rate

Similarly, the price of a risky (corporate) bond with spread z_τ relative to the default-free bond with maturity τ is expressed as:

$$p_\tau^{corp} = e^{-(r_\tau + z_\tau)\tau} = p_\tau e^{-z_\tau \tau}$$

If there is no default, the price between the corporate and default-free bond converge to par over τ. In case of default, creditors will recover a fraction of par, which is the recovery rate denoted as RR ($0 \leq RR \leq 1$).

As a simplifying assumption, suppose there will be no recovery of assets in default (i.e., RR = 0). Therefore, the corporate bond investor receives $1 (par) if no default and $0 if there is a default. On average, the expected value is:

$$e^{-\lambda_\tau^* \tau} \times 1 + \left(1 - e^{-\lambda_\tau^* \tau}\right) \times 0$$

On a present value basis discounting at risk-free rate generates:

$$e^{-r_\tau \tau}\left[e^{-\lambda_\tau^* \tau} \times 1 + \left(1 - e^{-\lambda_\tau^* \tau}\right) \times 0\right]$$

The final step is to equate this present value expression to the risky bond price and solve for λ^*_τ:

$$e^{-(r_\tau + z_\tau)\tau} = e^{-r_\tau \tau}\left[e^{-\lambda_\tau^* \tau} \times 1 + \left(1 - e^{-\lambda_\tau^* \tau}\right) \times 0\right]$$

Solving for the risk-neutral hazard rate when the recover rate is zero shows that $\lambda^*_\tau = z_\tau$. Thus, the interpretation of this analysis is that the credit spread (*z*-spread) is the hazard rate.

When we introduce a positive recovery rate, the analysis changes slightly:

$$e^{-(r_\tau + z_\tau)\tau} = e^{-r_\tau \tau}\left[e^{-\lambda^*_\tau \tau} \times 1 + \left(1 - e^{-\lambda^*_\tau \tau}\right) \times RR\right]$$

After solving for the risk-neutral hazard rate, we end up with the following approximation:

$$\lambda^*_\tau \approx \frac{z_\tau}{1 - RR}$$

Stated differently, the loss given default (1 – RR) times the default probability (hazard rate) is approximately equal to the credit spread (*z*-spread).

Example: Computing hazard rate

The three-year CDS on Bloomington Minerals and Mining has a spread of 400 basis points. The underlying nature of the business contains specialized equipment that has a limited resale potential. Thus, a credit analyst projects a 20% recovery rate in default. **Calculate** the hazard rate.

Answer:

$$\lambda^*_\tau \approx \frac{0.04}{1 - 0.2} = 0.05$$

LO 21.9: Describe advantages of using the CDS market to estimate hazard rates.

The primary advantage of using CDS to estimate hazard rates is that CDS spreads are observable. Although we can create a model for the hazard rate (the probability of default in the next period conditional on surviving until the current period), the estimated value would inherently be a guess. Instead, we can draw on the logic of a reduced form model to use the observable, liquid CDS to infer the estimates of the hazard rate.

Our previous analysis on estimating hazard rates did not fully capture the complexities of the bond market. First, published estimates of default probabilities are insufficient as they are typically provided for a one-year horizon which may not match the duration of the analysis. Second, few corporations issue zero-coupon bonds. One can view commercial paper as *de facto* zero-coupon bonds but the issuing universe is restricted to large, highly-rated corporations. CDS can overcome these difficulties because liquid contracts exist for several maturities (e.g., 1, 3, 5, 7 and 10 years are common). Furthermore, a large number of liquid CDS curves are available (800 in U.S. markets, 1,200 in international markets) and the contracts are more liquid than the underlying cash bonds (i.e., narrower spreads and more volume).

Hazard Rate Curves

LO 21.10: Explain how a CDS spread can be used to derive a hazard rate curve.

Constructing the hazard rate curve uses a bootstrapping methodology not that different from bootstrapping a yield curve (moving from coupon yield curve to zero-coupon yield curve). The CDS spreads provide several discrete maturities to extract hazard rates. We know from casual observation that the CDS curves can take a variety of shapes so the constant hazard rate assumption from before is not likely to hold in practice. Technically, hazard rates are measured every instant in time so the CDS data will only provide a few observable data points and will require some form of interpolation or piecewise construction to complete the curve.

Intuitively, the hazard rate can vary over time. We can represent the time-varying hazard rate as $\lambda(t)$. When the hazard rate varies, the probability of default becomes:

$$\pi_t = 1 - e^{-\int_0^t \lambda(s)ds}$$

For the special case when the hazard rate is constant (i.e., $\lambda(t) = \lambda$ for all t), then the PD expression simplifies to $\pi_t = 1 - e^{-\lambda t}$. For practical purposes, the hazard rates used in default models are not constant but will not vary each instant in time either. Therefore, using CDS spreads is a reasonable compromise to accommodate changing hazard rates at discrete points in time.

Using the common CDS maturities (1, 3, 5, 7 and 10 years), the time-varying hazard rate function can be expressed in general form. In the following expression, five piecewise constant hazard rates are determined from observed CDS spreads.

$$\lambda(t) = \begin{Bmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \end{Bmatrix} \quad \text{for} \quad \begin{Bmatrix} 0 < t \leq 1 \\ 1 < t \leq 3 \\ 3 < t \leq 5 \\ 5 < t \leq 7 \\ 7 < t \end{Bmatrix}$$

Subsequently, the integral in the probability of default equation given previously is determined as:

$$\int_0^t \lambda(s)ds = \begin{Bmatrix} \lambda_1 t \\ \lambda_1 + (t-1)\lambda_2 \\ \lambda_1 + 2\lambda_2 + (t-3)\lambda_3 \\ \lambda_1 + 2\lambda_2 + 2\lambda_3 + (t-5)\lambda_4 \\ \lambda_1 + 2\lambda_2 + 2\lambda_3 + 2\lambda_4 + (t-7)\lambda_5 \end{Bmatrix} \quad \text{for} \quad \begin{Bmatrix} 0 < t \leq 1 \\ 1 < t \leq 3 \\ 3 < t \leq 5 \\ 5 < t \leq 7 \\ 7 < t \end{Bmatrix}$$

Previously, the hazard rate was extracted from the default probability. This process relied on the simple idea that (PV of expected payments in default) = (PV of expected premiums paid). At CDS swap initiation no cash transfer takes place, but afterward if there is a change in credit quality, say, an improvement, the protection seller's position gains while the

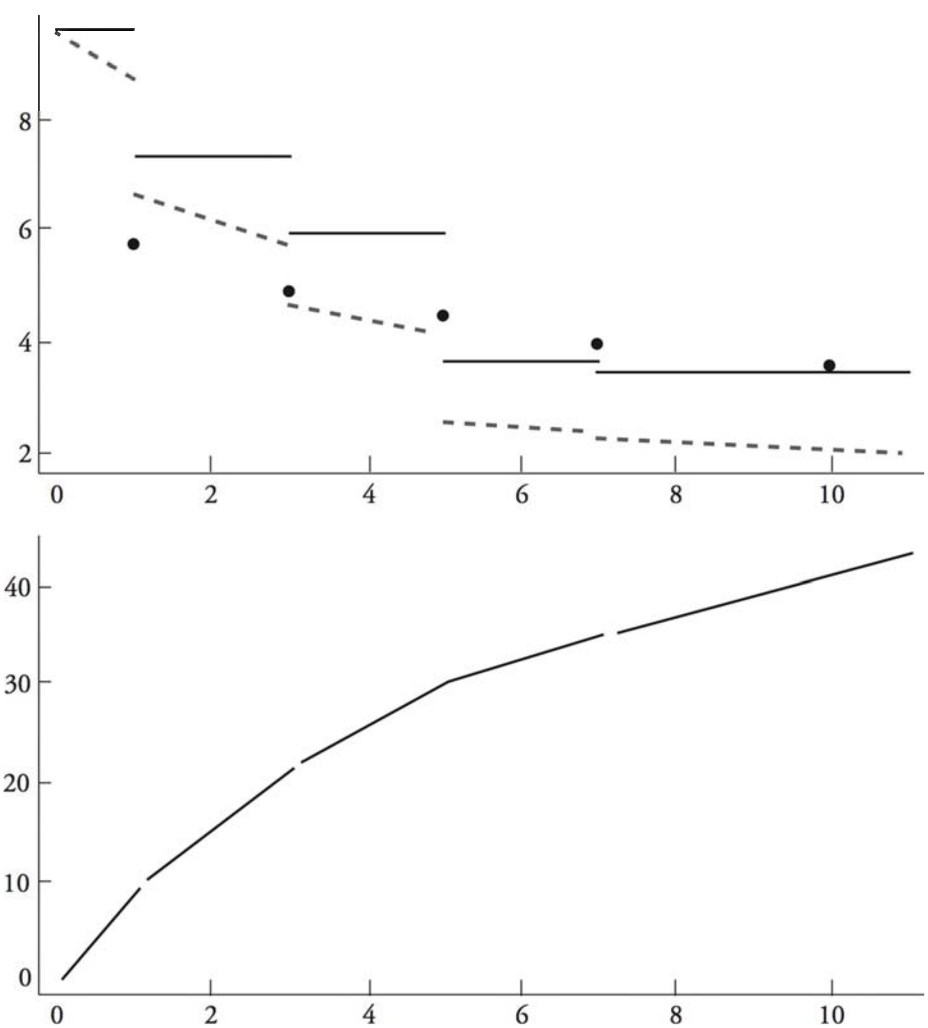
protection buyer's position loses (buyer is locked into paying too much for protection based on current conditions).

The fact that the CDS swap spread is observable allows for the inference of default probability for the 1-year maturity by equating (PV of expected payments in default) and (PV of expected premiums paid). Thus, given an assumed recovery rate (usually 40%), the probability of default and, hence, the hazard rate can be inferred for the first period (using the first piecewise portion of the earlier hazard function).

The bootstrapping procedure is then employed so that the hazard rate for the first period is used to infer the hazard rate for the second period from the piecewise function (using the observable information from the second CDS contract with a 3-year maturity, a recovery rate assumption, and the swap curve). Similarly, the hazard rate from the second period is an input to find the hazard in the third period, and so on. In this fashion, a graph can be constructed showing the CDS spreads, hazard rates, and default density.

CDS spreads (single points), the hazard rate curve (solid line), and default density (dashed line) are shown in the top graph in Figure 2. The default distribution, with a discontinuous slope when moving between hazard rates, is shown in the bottom graph in Figure 2.

Figure 2: Default Curve Estimation



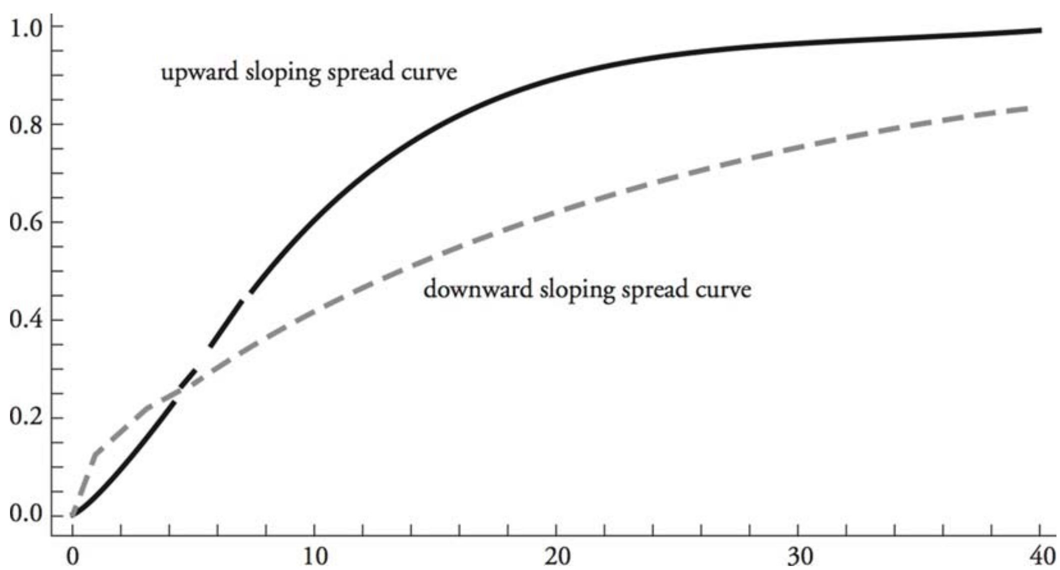
LO 21.11: Explain how the default distribution is affected by the sloping of the spread curve.

In order to explain how the slope of the spread curve affects the default distribution, it is useful to think of the term structure of the CDS spread curves. As a benchmark, consider the impact of spreads that are constant for all maturities, that is, the market's expectations for default is constant. In this case, the spread curve would be flat implying the probability of defaulting in the near term is the same as defaulting in the long run.

The most common spread curve is upward sloping. Thus, the aggregate market forecast is that default is unlikely in the near term but increases with the forecast period. In contrast, spread curves, although unusual, may be downward sloping. This phenomenon would indicate relatively high expectations of short-term default (distress) but, if the firm can right itself, it will likely survive for a sufficiently long period of time. Therefore, the longer-term spreads are lower than the short-term spreads. This situation is similar to an inverted yield curve where short-term rates are extremely high (likely from high, short-term inflation) but are expected to moderate to a more natural, lower rate in the future.

On a relative basis, a downward-sloping spread curve (dotted line) has a steeper default distribution than an upward-sloping spread curve (solid line), because the cumulative default for a short horizon is higher. Similarly, for intermediate and longer terms, the cumulative default distribution of the downward-sloping spread curve is flatter as the probability of default decreases after surviving the short term.

Figure 3: Default Distribution



Spread Risk

LO 21.12: Define spread risk and its measurement using the mark-to-market and spread volatility.

Spread risk is the risk of loss from changes in the price of securities that have a positive probability of default. By extension, the spread risk for Treasury securities is zero for any maturity. Recall that at the initiation of a CDS, the parties have implicitly agreed on a fair swap spread so that the expected payments to both are equal. Thus, no cash trades hands up-front. Rather, the protection buyer is exposed to the narrowing of spreads if the creditworthiness improves as it has essentially agreed to now-above-market premiums. Naturally, a loss that is experienced by the protection buyer (i.e., fee payer) represents a gain to the protection seller (i.e., contingent payer). Similarly, the protection seller suffers when spreads widen as it has agreed to provide contingent compensation in case of default at a rate that is now viewed as too low.

To measure spread risk, the mark-to-market of a CDS and spread volatility can be used. The mark-to-market effect is computed by shocking the entire CDS curve up and down by 0.5 basis points (similar to spread '01). Note the slight difference from spread '01 where the *z*-spread, a single value, was shocked. Thus, the entire CDS curve moves up and down by a parallel amount. An alternative measure of spread risk is to compute the volatility (standard deviation) of spreads. The spread volatility can use historical data or can be forward-looking based on a subjective probability distribution. Not surprisingly, the spread volatility spiked extremely high during the recent financial crisis for many financial services firms.

Key Concepts

LO 21.1

A credit spread represents the difference in yields between the security of interest (e.g., corporate bond) and a reference security (typically a higher rated instrument). There are several different ways to capture the concept of spread including: yield spread, i-spread, *z*-spread, asset-swap spread, CDS spread, OAS, and discount margin.

LO 21.2

The yield spread represents the difference between yield on the subject instrument and maturity-matched benchmark yield.

The i-spread (interpolated spread) uses linear interpolation when maturities do not match up precisely.

The CDS spread is the premium (percent of par) to protect against credit event.

The *z*-spread and OAS are computed rather than observed spreads. The *z*-spread is based on a hypothetical parallel shift of the benchmark curve to match the observed bond price. OAS is similar, but accommodates interest rate volatility and must be used for bonds with embedded options. *z*-spread = OAS when there are no embedded options.

LO 21.3

Analogous to DV01, the spread '01 computes the price change from a one basis point change in the *z*-spread. Computationally, the *z*-spread is increased and decreased by 0.5 basis points and the difference in resulting prices is the spread '01. This measure exhibits convexity, so as the spread increases, the marginal change in the spread '01 decreases.

LO 21.4

Bernoulli trials identify events as success (no default) and failure (insolvency) in each trial. The cumulative probability of default increases and, in the limit, all firms eventually default. The default process is memoryless – default in period (T_i, T_{i+1}) given no default until period i, is the same probability as default in the next period.

LO 21.5

Modeling defaults can be done by modeling the time to the next event using an exponential distribution. The number of defaults up to a certain time period follows a Poisson distribution.

LO 21.6

The hazard rate (or default intensity, λ) describes the likelihood of failure (default). When the hazard rate is constant, the arrival of the next default follows exponential distribution where cumulative default = $1 - e^{-\lambda t}$ and marginal probability of default is $\lambda e^{-\lambda t}$. This implies that the cumulative probability is increasing and all firms will eventually fail, and that the marginal probability of failure is decreasing.

LO 21.7

The conditional default probability computes the probability of default in the next period (distance of τ) given survival until the current period. If the hazard rate is constant over a very short time interval, then the conditional PD is calculated as $\lambda\tau$.

LO 21.8

Intuitively, risk-neutral default rates can be inferred from spreads. Given a fixed recovery rate and observable spread, the probability of default (hazard rate) can be approximated as:

$$\lambda_{\tau}^{*} \approx \frac{z_{\tau}}{1 - RR}$$

LO 21.9

CDS spreads are useful for estimating hazard rates because they are liquid, span multiple maturities and are standardized. These spreads provide more information about market expectations of default than typical default forecasts over the next period.

LO 21.10

More complex hazard rate models assume the hazard rate is time-varying.

The probability of default is used to back out the hazard rate for the first period (assuming the hazard rate is time-varying). The process is repeated for the next maturity (via bootstrapping) to estimate the next probability of default and hazard rate. This piecewise process is continued for several observable CDS maturities.

A default distribution curve can be constructed from a hazard rate curve. The slope of the default distribution curve will be discontinuous to reflect the movement from one hazard rate to the next.

LO 21.11

Spread curves may be upward sloping (typical shape) or downward sloping (short-term distress, but decreasing default risk if it can survive in the short term). Upward-sloping spread curves generate cumulative default distributions that are flatter in the short term but steeper afterward. Downward-sloping spread curves are steeper in the short term as the near probability of default is higher but then moderates to a flatter curve afterward.

LO 21.12

Spread risk is the change in value of risky securities from changing spreads. Similar to DV01 and spread '01 calculations, the entire CDS curve is shocked up and down by 0.5 basis points to compute the CDS mark-to-market value. Spread risk can also be measured using the historical or forward-looking standard deviation of credit spreads.

Concept Checkers

1. Which of the following statements is correct regarding spread measures?
   A. The yield spread and i-spread are equal if the benchmark yield curve is flat.
   B. The *z*-spread = OAS for callable bonds.
   C. The *z*-spread must be used for mortgage-backed securities (MBS).
   D. The CDS spread is used only with corporate bonds.

2. An analyst has noted that the default frequency in the pharmaceutical industry has been constant at 8% for an extended period of time. Based on this information, which of the following statements is most likely correct for a randomly selected firm following a Bernoulli distribution?

   I. The cumulative probability that a randomly selected firm in the pharmaceutical industry will default is constant.
   II. The probability that the firm survives for the next 6 years without default is approximately 60%.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. An analyst has gathered the following information about ABC Inc. and DEF Inc. The respective credit ratings are AA and BBB with 1-year CDS spreads of 200 and 300 basis points each. The associated probabilities of default based on published reports are 10% and 20%, respectively. Which of the following statements about the recovery rates is most likely correct?
   A. The market implied recovery rates are equal.
   B. The market implied recovery rate is higher for ABC.
   C. The market implied recovery rate is lower for ABC.
   D. The loss given default is higher for DEF.

4. Which of the following statements best explains the relationship between CDS spreads and hazard rates?
   A. Hazard rates are observable and can be used to infer credit spreads from backward induction.
   B. Credit spreads are observable and can be used to infer hazard rates from backward induction.
   C. Hazard rates are observable and can be used to infer credit spreads from bootstrapping.
   D. Credit spreads are observable and can be used to infer hazard rates from bootstrapping.

5. An analyst is studying the CDS spread curve for an established company. The 1-, 3- and 5-year spreads are 400 bps, 200 bps, and 150 bps, respectively. Which of the following interpretations of the data is most likely correct for the shape of the default distribution?

	Default Distribution	Near-Term Slope
A.	Upward sloping	flat slope
B.	Downward sloping	steep slope
C.	Upward sloping	steep slope
D.	Downward sloping	flat slope

Concept Checker Answers

1. **A** If the yield curve is flat, there is no need for interpolation. Therefore, yield spread = i-spread. *z*-spread > OAS for callable bonds. OAS must be used for MBS. CDS measures the credit risk from any security with positive probability of default including sovereign and municipal bonds.

2. **B** Statement I is false because the cumulative probability of default increases (i.e., even the highest rated companies will eventually fail over a long enough period). Statement II is true since the probability the firm survives over the next 6 years without default is: $(1 - 0.08)^6 =$ 60.6%

3. **C** The approximation of credit spread = (1 – RR) × (PD). This implies:

   ABC: 200 bps = (1 – RR)(10%), so RR = 80%

   DEF: 300 bps = (1 – RR)(20%), so RR = 85%

   Thus, the market implied recovery rate is lower for ABC. Using loss given default terminology, LGD for ABC = 20% and LGD for DEF = 15%.

4. **D** Credit spreads are observable and, when used in conjunction with observed discount rates on swaps and the presumed recovery rate, the probability of default over the specific maturity can be inferred. The probability of default can, in turn, infer the hazard rate for the first period. Using the bootstrapped hazard rate from period 1, the second period hazard rate can be inferred using the same procedure with observable data corresponding to the longer maturity.

5. **C** The CDS spreads indicate a downward sloping spread curve. Note that the cumulative distribution of default is always increasing regardless of the slope of the spread curve. In addition, since the short-term probability of default is relatively high, the slope in the near term of the default distribution function is relatively steep.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Portfolio Credit Risk

Topic 22

Exam Focus

In this topic, we discuss the role that default correlation plays in measuring the default risk for a credit portfolio. For the exam, be prepared to list drawbacks of using default correlation and explain the single-factor model approach under the assumption that defaults are independent and returns are normally distributed. Know how to calculate the mean and standard deviation of the default distribution under the single-factor model conditional approach for correlations of 0 and 1 and the unconditional approach for correlations between 0 and 1. Lastly, be able to explain how VaR is determined using the single-factor model and copula methodology based on simulated terminal values.

Default Correlation for Credit Portfolios

LO 22.1: Define and calculate default correlation for credit portfolios.

Risks to consider when analyzing credit portfolios include default probability, loss given default (LGD), probability of deteriorating credit ratings, spread risk, and risk of loss through restructuring in bankruptcy. **Default correlation** measures the probability of multiple defaults for a credit portfolio issued by multiple obligors.

Suppose there are two firms whose probabilities of default over the next time horizon t are π_1 and π_2 for each firm, respectively. In addition, there is a joint probability that both firms will default over time horizon t equal to π_{12}.

The default correlation for this simple two firm credit portfolio can be framed around the concept of Bernoulli-distributed random variables x_i, that have four possible outcomes over a specific time horizon t. Figure 1 illustrates the four possible random outcomes where 0 denotes the event of no default and 1 denotes default. The random variables for firm 1 and 2 are x_1 and x_2. The probabilities of the four random events (firm 1 defaults, firm 2 defaults, both firms default, and neither firm defaults) are illustrated in Figure 1.

Figure 1: Default Probabilities for Two Firms

Event	x_1	x_2	$(x_1\ x_2)$	*Default Probability*
Firm 1 Defaults	1	0	0	$\pi_1 - \pi_{12}$
Firm 2 Defaults	0	1	0	$\pi_2 - \pi_{12}$
Both Default	1	1	1	π_{12}
No Default	0	0	0	$1 - \pi_1 - \pi_2 + \pi_{12}$

Thus, the probability that one of the firms defaults or both firms default equals: $\pi_1 + \pi_2 - \pi_{12}$. Since the probabilities of all four events must equal 1, the probability that no firm defaults is $1 - \pi_1 - \pi_2 + \pi_{12}$. The means of the two Bernoulli-distributed default processes are: $E[x_i] = \pi_i$, where i equals 1 or 2. The expected value of joint default is simply the product of the two denoted as: $E[x_1x_2] = \pi_{12}$. The variances are computed as: $E[x_i]^2 - (E[x_i])^2 = \pi_i(1 - \pi_i)$ and the covariance is computed as: $E[x_1x_2] - E[x_1]E[x_2] = \pi_{12} - \pi_1 \pi_2$.

Equation 1 defines the default correlation for a two firm credit portfolio as the covariance of firm 1 and 2 divided by the standard deviations of firm 1 and 2.

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}} \tag{1}$$

Example: Calculating Default Correlation

Assume a portfolio of two credits, one rated BBB+ and one rated BBB, whose probabilities of default over the next time horizon *t* are 0.002 and 0.003, respectively. In addition, assume there is a joint probability that both credits will default over time horizon *t* equal to 0.00015. **Calculate** the default correlation for this credit portfolio.

Answer:

Default correlation can be calculated using the following formula for a two-credit portfolio:

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}} = \frac{0.00015-(0.002\times 0.003)}{\sqrt{0.002(1-0.002)}\sqrt{0.003(1-0.003)}}$$

$$= \frac{0.000144}{\sqrt{0.001996}\sqrt{0.002991}} = \frac{0.000144}{(0.04468\times 0.05469)}$$

$$= 0.0589 \text{ or } 5.89\%$$

Credit Portfolio Framework

LO 22.2: Identify drawbacks in using the correlation-based credit portfolio framework.

A major drawback of using the default correlation-based credit portfolio framework is the number of required calculations. For example, to specify all possible outcome events in a three firm framework requires three individual firm default outcome probabilities, three two-default outcome probabilities, the three-default outcome probability, and the no default outcome probability. Thus, there are 2^n event outcomes with only $(n + 1) + [n(n - 1) / 2]$ conditions. If we have ten firms, there will be 1,024 event outcomes with 56 conditions. The number of pairwise correlations is equal to $n(n - 1)$. In modeling credit risk, the pairwise correlations are often set to a single, non-negative parameter.

In addition, certain characteristics of credit positions do not fit well in the default correlation credit portfolio model. Guarantees, revolving credit agreements, and other contingent liabilities have features similar to options that are not reflective of this simplistic framework. For example, credit default swap (CDS) basis trades may not be modeled simply by credit or market risk. Rather technical factors may play an important role as was evident in the subprime mortgage crisis where there was a lack of liquidity. Furthermore, convertible bonds have characteristics of credit and equity portfolios driven by market and credit risks.

Additional drawbacks in using the default correlation-based credit portfolio framework are related to the limited data for estimating defaults. Firm defaults are relatively rare events. Therefore, estimated correlations vary greatly depending on the data time horizon and industry. Most studies use an estimated correlation of 0.05. Thus, default correlations are small in magnitude, and the joint probability of two firms defaulting is even smaller.

Credit VaR

LO 22.3: Assess the impact of correlation on a credit portfolio and its Credit VaR.

LO 22.5: Define and calculate Credit VaR.

The effects of default, default correlation, and loss given default are important determinants in measuring credit portfolio risk. A portfolio's **credit value at risk** (credit VaR) is defined as the quantile of the credit loss less the expected loss of the portfolio. Default correlation impacts the volatility and extreme quantiles of loss rather than the expected loss. Thus, default correlation affects a portfolio's credit VaR.

If default correlation is 1, then there are no credit diversification benefits, and the portfolio behaves as if there were just one credit position. A default correlation equal to 0 implies the portfolio is a binomial-distributed random variable because there is no correlation with other firms/credits.

Example: Computing credit VAR (default correlation = 1, number of credits = n)

Suppose there is a portfolio with a value of \$1,000,000 that has n credits. Each of the credits has a default probability of π percent and a recovery rate of zero. This implies that in the event of default, the position has no value and is a total loss.

What is the extreme loss given default and credit VaR at the 95% confidence level if π is 2% and the default correlation is equal to 1?

Answer:

With the default correlation equal to 1, the portfolio will act as if there is only one credit. Viewing the portfolio as a binomial-distributed random variable, there are only two possible outcomes for a portfolio acting as one credit. Regardless of whether the number of credits in the portfolio, n, is 1, 20, or 1,000, it will still act as one credit when the correlation is 1.

The portfolio has a π percent probability of total loss and a $(1 - \pi)$ percent probability of zero loss. Therefore, with a recovery rate of zero, the extreme loss given default is \$1,000,000. The expected loss is equal to the portfolio value times π and is \$20,000 in this example (0.02 × \$1,000,000). There is a 98% probability that the loss will be 0, given the fact that π equals 2%. The credit VaR is defined as the quantile of the credit loss minus the expected loss of the portfolio. Therefore, at the 95% confidence level, the credit VaR is equal to –\$20,000 (0 minus the expected loss of \$20,000).

Note that if π was greater than (1 – confidence level), the credit VaR would have been calculated as \$1,000,000 – \$20,000 = \$980,000.

Example: Computing credit VAR (default correlation = 0, number of credits = 50)

Again suppose there is a \$1,000,000 portfolio with n credits that each have a default probability of n percent and a zero recovery rate. However, in this example the default correlation is 0, n = 50, and π = 0.02. In addition, each credit is equally weighted and has a terminal value of \$20,000 if there is no default. The number of defaults is binomially distributed with parameters of n = 50 and π = 0.02. The 95th percentile of the number of defaults based on this distribution is 3. What is the credit VaR at the 95% confidence level based on these parameters?

Answer:

The expected loss in this case is also \$20,000 (\$1,000,000 × 0.02). If there are three defaults, the credit loss is \$60,000 (3 × \$20,000). The credit VaR at the 95% confidence level is \$40,000 (calculated by taking the credit loss of \$60,000 and subtracting the expected loss of \$20,000).

The term "granular" refers to reducing the weight of each credit as a proportion of the total portfolio by increasing the number of credits. As a credit portfolio becomes more granular, the credit VaR decreases. However, when the default probability is low, the credit VaR is not impacted as much when the portfolio becomes more granular.

Example: Computing credit VaR (default correlation = 0, number of credits = 1,000)

Suppose there is a \$1,000,000 portfolio with n credits that each have a default probability, π, equal to 2% and a zero recovery rate. The default correlation is 0 and n = 1,000. There is a probability of 28 defaults at the 95th percentile based on the binomial distribution with the parameters of n = 1,000 and π = 0.02. What is the credit VaR at the 95% confidence level based on these parameters?

Answer:

The 95th percentile of the credit loss distribution is \$28,000 [28 × (\$1,000,000 / 1,000)] The expected loss in this case is \$20,000 (\$1,000,000 × 0.02). The credit VaR is then \$8,000 (\$28,000 – expected loss of \$20,000).

Thus, as the credit portfolio becomes more granular, the credit VaR decreases. For very large credit portfolios with a large number of independent credit positions, the probability that the credit loss equals the expected loss eventually converges to 100%.

Conditional Default Probabilities

LO 22.4: Describe the use of a single factor model to measure portfolio credit risk, including the impact of correlation.

The **single-factor model** is used to examine the impact of varying default correlations based on a credit position's beta. Each individual firm or credit, i, has a beta correlation, β_i, with the market, m. Firm i's individual asset return is defined as:

$$a_i = \beta_i m + \sqrt{1-\beta_i^2}\,\varepsilon_i \tag{2}$$

where:

$\sqrt{1-\beta_i^2}$ = firm's standard deviation of idiosyncratic risk

ε_i = firm's idiosyncratic shock

Assuming that each ε_i is not correlated with other credits, each return on asset, a_i, is a standard normal variate. The correlation between pairs of individual asset returns between two firm's i and j is $\beta_i\beta_j$. The model assumes that firm i defaults if $a_i \leq k_i$, the logarithmic distance to the defaulted asset value that is measured by standard deviations.

An important property of the single-factor model is conditional independence. Conditional independence states that once asset returns for the market are realized, default risks are

independent of each other. This is due to the assumption for the single-factor model that return and risk of assets are correlated only with the market factor. The property of conditional independence makes the single-factor model useful in estimating portfolio credit risk.

So, how can the single-factor model be used to measure default probabilities that are conditional on market movements or economic health? Suppose that the market factor, m, has a specific value of $\bar{m}$. Substituting this value $\bar{m}$ into Equation 2 and subtracting $\beta_i \bar{m}$ from both sides results in Equation 3. Default risk is measured by the distance to default, $a_i - \beta_i \bar{m}$. This distance to default either increases or decreases, and the only random parameter is the idiosyncratic shock, ε_i.

$$a_i - \beta_i \bar{m} = \sqrt{1-\beta_i^2}\,\varepsilon_i \tag{3}$$

As a result of this conditioning, the default distribution's mean shifts based on the specific market value for any beta, β_i, that is greater than zero. The default threshold, k_i, does not change, but the standard deviation of the default distribution is reduced from 1 to $\sqrt{1-\beta_i^2}$.

The unconditional default distribution is a standard normal distribution. However, the conditional distribution is a normal distribution with a mean of $\beta_i \bar{m}$ and a standard deviation of $\sqrt{1-\beta_i^2}$. Specifying a specific value $\bar{m}$ for the market parameter, m, in the single-factor model results in the following implications:

1. The conditional probability of default will be greater or smaller than the unconditional probability of default as long as $\bar{m}$ or β_i are not equal to zero. This reduces the default triggers or number of idiosyncratic shocks, ε_i, so that it is less than or equal to $k_i - \beta_i \bar{m}$. As the market factor goes from strong to weak economies, a smaller idiosyncratic shock will trigger default.

2. The conditional standard deviation $\sqrt{1-\beta_i^2}$ is less than the unconditional standard deviation of 1.

3. Individual asset returns, a_i, and idiosyncratic shocks, ε_i, are independent from other firms' shocks and returns.

Conditional Default Distribution Variance

Suppose a firm has a beta, β_i, equal to 0.5 and a default threshold, k_i, equal to –2.33. The unconditional probability of default $\Phi(-2.33) = 0.01$. If the market return is –0.5, what is the conditional variance of the default distribution using the single-factor model?

Professor's Note: Recall that the symbol Φ represents a standard normal distribution function.

The conditional distribution is a normal distribution with a mean of $\beta_i \bar{m}$ and a conditional variance of $1-\beta_i^2$. For this example, the mean is $\beta_i \bar{m} = 0.5(-0.5) = -0.25$, and the conditional variance is $1 - 0.5^2 = 0.75$. The conditional standard deviation is then 0.866 (the square root of the variance of 0.75).

The conditional cumulative default probability function is stated as a function of *m* as follows:

$$p(m) = \Phi\left(\frac{k_i - \beta_i \bar{m}}{\sqrt{1-\beta_i^2}}\right)$$

The mean is the new distance to default based on the realized market factor, $\beta_i \bar{m}$, and the standard deviation assumes conditional independence and is equivalent to $\sqrt{1-\beta_i^2}$. Thus, given a realized market factor, $\bar{m}$, the probability of default is based on the distance of the new default trigger of idiosyncratic shocks, ε_i, measured in standard deviations below its mean of zero.

Professor's Note: For the exam, focus on how to calculate the parameters of the distribution (e.g., the mean and the standard deviation).

If we assume that distribution parameters (β, k, and π) are equal for all firms, then the probability of a joint default for two firms can be defined as:

$$\Phi\begin{pmatrix} k \\ k \end{pmatrix} = P[-\infty \leq a \leq k, -\infty \leq a \leq k]$$

This assumption also allows us to define the default correlation for any pair of firms as follows:

$$\rho = \frac{\Phi\begin{pmatrix} k \\ k \end{pmatrix} - \pi^2}{\pi(1-\pi)} \qquad (4)$$

Although the derivation of this default correlation equation is not required for the exam, you may wish to understand how Equation 1 (from LO 22.1) is used to derive Equation 4.

The single-factor model assumes the cumulative return distribution of any pair of credit positions *i* and *j* is distributed as a bivariate standard normal distribution with a correlation coefficient equal to $\beta_i\beta_j$. The cumulative distribution function for this pair, *i* and *j*, is $\Phi\begin{pmatrix} a_i \\ a_j \end{pmatrix}$. We are interested in the probability of a joint default that will occur in the extreme tail of the distributions. Thus, the probability that the realized value for credit *i*, a_i, is less than the default threshold, or critical value, k_i, and is denoted for the pair of credits *i* and *j* as:

$$\Phi\begin{pmatrix} k_i \\ k_j \end{pmatrix} = P\left[-\infty \leq a_i \leq k_i, -\infty \leq a_j \leq k_j\right]$$

In LO 22.1, Equation 1 defined the default correlation as the covariance of firm 1 and 2 divided by the standard deviations of firm 1 and 2 as follows:

$$\rho_{ij} = \frac{\pi_{ij} - \pi_i \pi_j}{\sqrt{\pi_i(1-\pi_i)}\sqrt{\pi_j(1-\pi_j)}}$$

Substituting $\Phi\begin{pmatrix}k_i\\k_j\end{pmatrix}$ for π_{ij} results in:

$$\rho_{ij}=\frac{\Phi\begin{pmatrix}k_i\\k_j\end{pmatrix}-\pi_i\pi_j}{\sqrt{\pi_i(1-\pi_i)}\sqrt{\pi_j(1-\pi_j)}}$$

If we assume that parameters (β, k, and π) are equal for all firms, then the pairwise asset return correlation for any two firms must equal β^2 and the previous equation simplifies to Equation 4.

Credit VaR with a Single-Factor Model

Previously, the loss distribution was estimated when the default correlation was either 0 or 1. In order to define the distribution of loss severity for values between 0 and 1, we need to determine the unconditional probability of default loss. Using the single-factor model framework, the unconditional probability of a default loss level is equal to the probability that the realized market return results in a default loss. In other words, the individual credit asset returns, a_i, are strictly a function of the market return and the asset return's correlation, or β_i, with the market. The unconditional distribution used to calculate credit VaR is determined by the following steps:

1. The default loss level is assumed to be a random variable X with realized values of x. Under this framework, x is not simulated.

2. Given a loss level of x, the value for the market factor, m, is determined at the probability of the stated loss level. The relationship between the loss level and market factor return is equal to:

   $$x(m)=p(m)=\Phi\left(\frac{k-\beta\overline{m}}{\sqrt{1-\beta^2}}\right)$$

   The market factor return, $\overline{m}$, for a given loss level, $\overline{x}$, is determined based on the following relationship:

   $$\Phi^{-1}(\overline{x})=\left(\frac{k-\beta\overline{m}}{\sqrt{1-\beta^2}}\right)$$

3. The market factor is assumed to be standard normal, and therefore, a loss level of 0.01 (99% confidence level) is equal to a value of –2.33 based on the standard normal distribution.

4. These steps are repeated for each individual credit to determine the loss probability distribution.

Example: Realized market value

Suppose a credit position has a correlation to the market factor of 0.25. What is the realized market value used to compute the probability of reaching a default threshold at the 99% confidence level?

Answer:

At the 99% confidence level, the default loss level has a default probability, π, of 0.01. A default loss level of 0.01 corresponds to –2.33 on the standard normal distribution. The relationship between the default loss level and the given market return, $\bar{m}$, is defined by:

$$p(\bar{m}) = 0.01 = \Phi\left(\frac{k - \beta\bar{m}}{\sqrt{1-\beta^2}}\right)$$

This is approximately equal to the probability of obtaining a realized market return of –2.33 as follows:

$$\Phi^{-1}(0.01) \approx -2.33 = \left(\frac{k - \beta\bar{m}}{\sqrt{1-\beta^2}}\right)$$

The realized market value is computed as follows:

$$-2.33 = \frac{-2.33 - (0.25)\bar{m}}{\sqrt{1-0.25^2}}$$
$$-2.33(0.9682) = -2.33 - (0.25)\bar{m}$$
$$-2.256 + 2.33 = -(0.25)\bar{m}$$
$$0.074 = -(0.25)\bar{m}$$
$$-0.296 = \bar{m}$$

The probability that the default threshold is reached is the same probability that the realized market return is –0.296 or lower.

The parameters play an important role in determining the unconditional loss distribution. The probability of default, π, determines the unconditional expected default value for the credit portfolio. The credit position's correlation to the market, β, determines the dispersion of the defaults based on the range of the market factor.

Credit VaR with Copulas

LO 22.6: Describe how Credit VaR can be calculated using a simulation of joint defaults.

Copulas provide a mathematical approach for determining how defaults are correlated with one another using simulated results. The following four steps are used to compute a credit VaR under the copula methodology:

1. Define the copula function.
2. Simulate default times.
3. Obtain market values and profit and loss data for each scenario using the simulated default times.
4. Compute portfolio distribution statistics by adding the simulated terminal value results.

Example: Computing credit VaR with a copula

Suppose there is a credit portfolio with two loans (rated CCC and BB) that each has a notional value of $1,000,000. Figure 2 illustrates four possible event outcomes over a default time horizon of one year for this credit portfolio. The four event outcomes are only the BB rated loan defaults, only the CCC rated loan defaults, both loans default, or no loans default.

Figure 2: Event outcomes for a two credit portfolio

Event	*Default Time*
BB Default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} > 1)$
CCC Default	$(\tau_{BB,i} > 1, \tau_{CCC,i} \leq 1)$
Both Default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} \leq 1)$
No Default	$(\tau_{BB,i} > 1, \tau_{CCC,i} > 1)$

How can credit VaR be estimated for this portfolio assuming a correlation of 0.25?

Answer:

The copula approach to estimating credit VaR is applied using the following steps:

1. The first step is to simulate 1,000 values using a copula function. The most common copula used to calculate credit VaR is the normal copula.

2. The 2,000 simulated values (1,000 pair simulations results in 2,000 values) are then mapped to their standard univariate normal quantile which results in 1,000 pairs of probability values.

3. The first and second elements of each probability pair are mapped to the BB and CCC default times, respectively.

4. A terminal value is assigned to each loan for each simulation. The values are added up for the two loans, and the sum of the no-default event value is subtracted to determine the loss. Figure 3 summarizes the sum of the terminal values and losses for 1,000 simulations.

Figure 3: Event outcomes for a two credit portfolio

Event	*Default Time*	*Terminal Value*	*Loss*
BB Default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} > 1)$	1,480,000	710,000
CCC Default	$(\tau_{BB,i} > 1, \tau_{CCC,i} \leq 1)$	1,410,000	780,000
Both Default	$(\tau_{BB,i} \leq 1, \tau_{CCC,i} \leq 1)$	700,000	1,490,000
No Default	$(\tau_{BB,i} > 1, \tau_{CCC,i} > 1)$	2,190,000	0

The loss level sums from the simulation are then used to determine the credit VaR based on the simulated distribution. In this simulation, the 99% confidence level corresponds to the \$1,490,000 loss where both loans default. The 95% confidence level corresponds to the \$780,000 value because the lower 5% of the simulated values resulted in defaults with a total loss of \$780,000.

Key Concepts

LO 22.1

The default correlation for a two credit portfolio assuming the outcomes are Bernoulli-distributed random variables is:

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

LO 22.2

Drawbacks of using the default correlation-based credit portfolio framework are the number of required calculations (2^n event outcomes with $(n + 1) + [n(n - 1) / 2]$ conditions), certain characteristics of credit positions do not fit well in the default correlation credit portfolio model, and the limited data for estimating defaults due to the fact that firm defaults are relatively rare events.

LO 22.3

Default correlation affects a portfolio's credit value at risk (credit VaR). A default correlation equal to 0 implies the portfolio is a binomially distributed random variable. As a credit portfolio becomes more granular, the credit VaR decreases.

LO 22.4

In the single-factor model, firm *i*'s individual asset return is defined as:
$a_i = \beta_i m + \sqrt{1-\beta_i^2}\varepsilon_i$ where $\sqrt{1-\beta_i^2}$ is the firm's standard deviation of idiosyncratic risk, and ε_i is the firm's idiosyncratic shock. The model assumes that firm i defaults if $a_i \le k_i$.

The single-factor model framework states that the unconditional probability of a default loss level is equal to the probability that the realized market return results in a default loss. The market factor is assumed to be standard normal. The credit position's correlation to the market, β, determines the dispersion of the defaults based on the range of the market factor.

LO 22.5

A portfolio's credit VaR can be defined as the quantile of the credit loss less the expected loss of the portfolio.

LO 22.6

A credit VaR under the copula methodology is computed by: defining the copula function, simulating default times, obtaining market values and profit and loss data for each scenario using the simulated default times, and computing the portfolio distribution statistics by adding the simulated terminal value results.

Concept Checkers

1. Which of the following equations best defines the default correlation for a two firm credit portfolio?
   A. $\rho_{12} = \dfrac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$
   B. $\rho_{12} = \dfrac{\pi_{12}}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$
   C. $\rho_{12} = \dfrac{\pi_{12}}{\sqrt{(1-\pi_1)}\sqrt{(1-\pi_2)}}$
   D. $\rho_{12} = \dfrac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1}\sqrt{\pi_2}}$

2. Suppose a portfolio manager is using a default correlation framework for measuring credit portfolio risk. How many unique event outcomes are there for a credit portfolio with eight different firms?
   A. 10.
   B. 56.
   C. 256.
   D. 517.

3. Suppose a portfolio has a notional value of $1,000,000 with 20 credit positions. Each of the credits has a default probability of 2% and a recovery rate of zero. Each credit position in the portfolio is an obligation from the same obligor, and therefore, the credit portfolio has a default correlation equal to 1. What is the credit value at risk at the 99% confidence level for this credit portfolio?
   A. $0.
   B. $1,000.
   C. $20,000.
   D. $980,000.

4. A portfolio manager uses the single-factor model to estimate default risk. What is the mean and standard deviation for the conditional distribution when a specific realized market value $\bar{m}$ is used?
   A. The mean and standard deviation are equivalent in the standard normal distribution.
   B. The mean is $\beta_i\bar{m}$ and the standard deviation is $\sqrt{1-\beta_i^2}$.
   C. The mean is $\bar{m}$ and the standard deviation is β_i.
   D. The mean is $\bar{m}$ and the standard deviation is 1.

5. Suppose a credit position has a correlation to the market factor of 0.5. What is the realized market value that is used to compute the probability of reaching a default threshold at the 99% confidence level?
   A. –0.2500.
   B. –0.4356.
   C. –0.5825.
   D. –0.6243.

Concept Checker Answers

1. **A** The default correlation for a two firm credit portfolio is defined as:

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

2. **C** There are 256 event outcomes for a credit portfolio with eight different firms calculated as: $2^8 = 256$.

3. **D** With the default correlation equal to 1, the portfolio will act as if there is only one credit. Viewing the portfolio as a binomial distributed random variable, there are only two possible outcomes for a portfolio acting as one credit. The portfolio has a 2% probability of total loss and a 98% probability of zero loss. Therefore, with a recovery rate of zero, the extreme loss given default is $1,000,000. The expected loss is equal to the portfolio value times π and is $20,000 in this example (0.02 × $1,000,000). The credit VaR is defined as the quantile of the credit loss less the expected loss of the portfolio. At the 99% confidence level, the credit VaR is equal to $980,000 ($1,000,000 minus the expected loss of $20,000).

4. **B** The conditional distribution is a normal distribution with a mean of $\beta_i \bar{m}$ and a standard deviation of $\sqrt{1-\beta_i^2}$.

5. **D** A default loss level of 0.01 corresponds to –2.33 on the standard normal distribution. The realized market value is computed as follows:

$$-2.33 = \frac{-2.33 - (0.5)\bar{m}}{\sqrt{1-0.5^2}}$$

$$-2.33(0.86603) = -2.33 - (0.5)\bar{m}$$

$$-2.01785 + 2.33 = -(0.5)\bar{m}$$

$$0.31215 = -(0.5)\bar{m}$$

$$-0.62430 = \bar{m}$$

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Structured Credit Risk

Topic 23

Exam Focus

In this topic, we discuss common structured products, capital structure in securitization, structured product participants, a basic waterfall structure, and the impact of correlation. For the exam, understand the qualitative impacts of changing default probability and default correlation for all tranches for mean (average) and risk (credit VaR). Default sensitivity (similar to DV01) is introduced. Understand the process to compute implied correlation extracted from observable market prices.

Types of Structured Products

LO 23.1: Describe common types of structured products.

Securitization and structured products are two of the most important financial innovations in recent memory. Securitization is basically the pooling of credit-sensitive assets and the associated creation of new securities (structured products or portfolio credit products) whose cash flows are based on underlying loans or credit claims. Each product has its own risk and return characteristics, which can vary dramatically from the original assets. For this LO, a partial list of structured products and factors that affect their valuation are discussed.

Covered bonds. Covered bonds are on-balance sheet securitizations. A pool of mortgages, which secure a bond issue, is separated from other loans into a covered pool on the originator's balance sheet. Investors have higher priority than general creditors if a bank defaults. Principal and interest is paid and guaranteed by the originator and is not based on the performance of the underlying assets themselves. Thus, covered bonds are not true securitizations since the assets are not part of a bankruptcy-remote structure and the investors have recourse against the originator.

Mortgage pass-through securities. In contrast to covered bonds, mortgage pass-through securities are true off-balance sheet securitizations. Investors receive cash flows based entirely on the performance of the pool less associated fees paid to the servicer. Most pass-throughs are agency mortgage-backed securities (MBS) that carry implicit or explicit government guarantee of performance. Thus, default risk is not a serious concern. The primary risk is due to prepayment of principal by the homeowner, most likely from refinancing after interest rate declines or home sales.

Collateralized mortgage obligations (CMOs). CMOs are MBSs that tranche (i.e., divide) cash flows into different securities based on predetermined conditions. The resulting tranches can have long or short maturities, fixed or floating cash flows, or other varieties and conditions. The most basic structure is the *waterfall* or *sequential pay structure* where Tranche 1 receives all principal and its portion of interest in each period until it is paid

off. The remaining tranches will receive interest only until Tranche 1 is retired and then principal will flow down to Tranche 2, and so on. Not surprisingly, Tranche 1 will have a very low prepayment risk as it expects to receive all principal payments before other bondholders.

Structured credit products. Like other structured products, this pool of assets is backed by risky debt instruments. The difference is that structured credit products create tranches that have different amounts of credit risk. The most junior (i.e., equity) tranches bear the first losses and are most likely to be written down from defaulted assets. If the equity tranche is completely wiped out, the next most junior tranche will bear the credit risk of subsequent defaults. The most senior tranche will have the highest credit rating and the lowest probability of writedowns.

Asset-backed securities. This is the most general class of securitizations where cash-flow generating assets are pooled and subsequently tranched. Under this definition, MBS is a special case of the more general ABS. Other varieties include collateralized bond obligations (CBO), collateralized debt obligations (CDO), collateralized loan obligations (CLO), and collateralized mortgage obligations (CMO). There exist even more complex securities that pool other securitizations together such as CDO-squared (CDO of CDOs).

Structured credit products can also vary across other dimensions. First, the underlying collateral of the pool can consist of loans, bonds, credit card receivables, auto loans, and even non-debt instruments that generate cash flows, such as toll collections. Second, the size and number of tranches is specific to each transaction. Third, the pool can be passive or actively managed. In a passive pool, the existing assets, such as mortgages and auto loans, will eventually pay themselves down. On the other hand, actively managed pools will selectively add or shed assets from the pool. Managers with key insight should be able to enhance the performance of the pool by identifying overvalued and undervalued loan products. Revolving pools have a period of time where loan proceeds are reinvested in new assets. Once the revolving period ends, the asset balances are fixed (e.g., credit card balances) and will spend themselves down.

Capital Structure in Securitization

LO 23.2: Describe tranching and the distribution of credit losses in a securitization.

The capital structure of a securitization refers to the priority assigned to the different tranches. In general, the most **senior tranches** at the top of the capital structure will have the highest priority to receive principal and interest. Since these securities are perceived to be the safest, they also receive the lowest coupon.

The **equity tranche** is the slice of the cash flow distribution with the lowest priority and will absorb the first losses up to a prespecified level. These securities typically do not carry a fixed coupon but receive the residual cash flows only after the other security claims are satisfied. Therefore, the return is variable and, hence, the term “equity.” Typically, the equity tranche is the smallest part of the capital structure.

Between the senior and equity tranches is the **mezzanine tranche** (i.e., the junior tranche). The mezzanine tranches will absorb losses only after the equity tranche is completely written down. Thus, the senior tranches are protected by both the equity and mezzanine debt (termed subordination or credit enhancement). Terminology-wise, the mezzanine debt attaches to the equity tranche from above and detaches from the senior tranche from below. These junior debt claims offer a relatively high coupon (if the claim is fixed) or high spread (if the claim is floating). To keep the securitization viable, the mezzanine tranches will be purposefully thin.

There are many creative ways to provide credit protection to various security classes, but this must come at the expense of shifting risk to other parts of the capital structure. In general, credit enhancement can be divided into internal and external credit enhancement mechanisms. The term **external credit enhancement** means that the credit protection takes the form of insurance or wraps purchased from a third party, typically a monoline insurer.

Two examples of **internal credit enhancements** are overcollateralization and excess spread. **Overcollateralization** is when the pool offers claims for less than the amount of the collateral. For example, consider a collateralized MBS with 101 mortgages in the collateral pool, but the face value of the bonds across all tranches only totals 100 mortgages. Overcollateralization is a *hard credit enhancement* because the protection is available at the origination of the pool.

The **excess spread** is the difference between the cash flows collected and the payments made to all bondholders. For example, if the weighted average of the collateral is 8% (net of fees) and the weighted average of the payments promised to the senior, junior, and equity tranches is 7%, then the residual 1% accumulates in a separate trust account. The excess spread will be invested and is available to make up future shortfalls. Since the excess spread is zero at origination, it is considered a *soft credit enhancement*.

Waterfall Structure

LO 23.3: Describe a waterfall structure in a securitization.

A waterfall structure outlines the rules and conditions that govern the distribution of collateral cash flows to different tranches. In the simplest example of a securitization, the senior and junior bonds will receive their promised coupons conditional on a sufficient amount of cash inflows from the underlying loans. The residual cash flow, if any, is called the excess spread. The overcollateralization triggers will decide how the excess is divided between the equity investors and the accumulating trust. Intuitively, the underlying cash flows will be largest in the earlier periods so the trust will build up a reserve against future shortfalls.

In practice, this process can be quite complex as there may be a dozen tranches or more with different coupons, maturities, and overcollateralization triggers. The waterfall is further complicated by loan defaults. A simplifying assumption would incorporate a constant default rate which can be built into the waterfall distribution. As the loans mature, the actual incidence of the loan defaults will increase or decrease the value of the respective tranches. For example, suppose that fewer loans default than previously assumed, then

collateral cash flows are larger than expected and will benefit all bondholders, in particular, the equity tranche.

Let's analyze the cash flows in a waterfall structure by considering the following examples. Assume there are 1,000 identical loans with a value of $1 million each. The interest rate on the loans is floating with a rate equal to LIBOR + 300 bps, reset annually. The senior, junior, and equity tranches are 80%, 15%, and 5% of the pool, respectively. The spreads on the senior and mezzanine tranches are 1% and 5%. There is one overcollateralization trigger where the equity holders are entitled to a maximum of $15 million and any excess is diverted to the excess trust account. To begin, assume the default rate is 0%. The cash flows for the waterfall structure are detailed in Figure 1.

Figure 1: Waterfall Structure (Default Rate = 0%)

Loan Information	
# loans	1,000
$ value of identical loan	$1,000,000
Principal amount	$1,000,000,000
LIBOR	5.00%
Spread	3.00%
Coupon	8.00%
Default rate	0.00%
OC trigger	$15,000,000

Tranche Information			
Senior % of pool		80%	
	LIBOR		5.00%
	Spread		1.00%
	Coupon		6.00%
Mezzanine % of pool		15%	
	LIBOR		5.00%
	Spread		5.00%
	Coupon		10.00%
Equity % of pool		5%	

Period	*Loan Proceeds*	
1	$80,000,000	
Senior Principal	*Senior Coupon*	*Interest*
$800,000,000	6.00%	$48,000,000
Mezzanine Principal	*Mezzanine Coupon*	*Interest*
$150,000,000	10.00%	$15,000,000
Excess CF	*CF to Equity*	*CF to Trust*
$17,000,000	$15,000,000	$2,000,000

Note that the senior tranche has a principal value of $800 million while the junior tranche has an initial principal of $150 million. Using a current LIBOR of 5%, their respective coupons are 6% (5% + 1% spread) and 10% (5% + 5% spread). The total cash flows flowing into the pool are $1 billion × 8% = $80 million, which is sufficient to pay the senior and junior claims. The residual cash flow is $80 million – ($48 million + $15 million) = $17 million.

Next, the overcollateralization test must be applied. Since the maximum the equity tranche can receive is $15 million, the equity investors will receive the full $15 million and the excess of $2 million will flow into the trust account. This is shown in the last row of Figure 1.

Now assume that the expected default rate is 4% each year. The first difference from the 0% default rate example is that the total loan proceeds is reduced by defaulted loans: $1 billion × 8% × (1 – 0.04) = $76.8 million. There is still sufficient cash flow to pay the senior and junior bondholders in full. However, when the overcollateralization test is applied, the equity holders will not reached their maximum. Therefore, the equity tranche receives only $13.8 million and there is no diversion to the trust account as shown in Figure 2.

Figure 2: Waterfall Structure (Default Rate = 4%)

Loan Information	
# loans	1,000
$ value of identical loan	$1,000,000
Principal amount	$1,000,000,000
LIBOR	5.00%
Spread	3.00%
Coupon	8.00%
Default rate	4.00%
OC trigger	$15,000,000

Tranche Information			
Senior % of pool		80%	
	LIBOR		5.00%
	Spread		1.00%
	Coupon		6.00%
Mezzanine % of pool		15%	
	LIBOR		5.00%
	Spread		5.00%
	Coupon		10.00%
Equity % of pool		5%	

Figure 2 Cont.: Waterfall Structure (Default Rate = 4%)

Period	*Loan Proceeds*	
1	$76,800,000	
Senior Principal	*Senior Coupon*	*Interest*
$800,000,000	6.00%	$48,000,000
Mezzanine Principal	*Mezzanine Coupon*	*Interest*
$150,000,000	10.00%	$15,000,000
Excess CF	*CF to Equity*	*CF to Trust*
$13,800,000	$13,800,000	$0

Securitization Participants

LO 23.4: Identify the key participants in the securitization process, and describe conflicts of interest that can arise in the process.

The nature of the securitization process from original loan to tranche issuance necessarily involves many different participants. The first step begins with the **originator** who funds the loan. The originator may be a bank, mortgage lender, or other financial intermediary. The term "sponsor" may be used if the originator supplies most of the collateral for the issue.

The **underwriter** performs a function similar to the issuance of traditional debt and equity. The underwriter structures the issue (i.e., engineers the tranche size, coupon, and triggers, and sells the bonds to investors). The underwriter warehouses the collateral and faces the risks that the issue will not be marketed or that the collateral value will drop.

The **credit rating agencies** (CRAs) are an important part of the securitization process. Without their explicit approval via credit ratings, investors would be at a severe disadvantage to assess the riskiness of the issue. The credit rating agencies can influence the size of the tranches by selecting the attachment points and thus are active participants in the process. In addition, the CRAs may influence the issue by requiring enhancements. There is a natural conflict of interest because the CRAs want to generate profit and grow their business, but it may come at the expense of allocating larger portions of the capital structure to lower interest paying senior notes. Investors can alleviate this concern by performing their own (costly) analysis or purchasing a wrap or insurance against the issue.

The role of the servicer is multifaceted and possibly understated. The servicer must collect and distribute the collateral cash flows and the associated fees. In addition, the servicer may need to provide liquidity if payments are late and resolve default situations. It is not hard to envision the conflict of interest in foreclosure: the servicer would, all else equal, like to delay foreclosure to increase their fees, while investors want as quick of a resolution as possible to minimize the damage and/or lack of maintenance from the homeowners who have no economic incentive to maintain the property.

When the pool is actively managed, another source of conflict arises. The manager naturally would like to minimize their effort to continually monitor the credit quality of the collateral unless there is a clear incentive to do so. A common feature of securitized pools is for the originator and/or manager to bear the first loss in the capital structure.

Custodians and trustees play an administrative role verifying documents, disbursing funds, and transferring funds between accounts.

Three-Tiered Securitization Structure

LO 23.5: Compute and evaluate one or two iterations of interim cashflows in a three-tiered securitization structure.

The cash flows in a three-tiered securitization (senior, mezzanine, and equity) can be broken out into the inflows from the collateral and the outflows to the investors. The inflows prior to maturity are the interest on the collateral (L_t) plus the recovery from the sale of any defaulted assets in the current period (R_t). Assume the collateral pool has N identical loans with coupons = LIBOR + spread. The terminal cash flows in the final year are the last interest payment plus principal and recovery of defaulted assets. As an additional consideration, the recovered funds from defaults would earn interest over the remaining life of the pool at r.

The outflows are the coupon payments paid to senior and mezzanine note holders, collectively denoted B (assumed constant). The equity holder position is a bit more complicated because the excess spread trust has first priority on the cash flows to provide soft credit enhancement to the more senior tranches. Specifically, the equity holders' cash flows are dependent on the amount of inflows to the pool less any funds diverted to the excess spread account. Denote the amount diverted to the spread trust in year t as (OC_t) with maximum allowable diversion K. To determine the cash flow to equity, the following steps must be performed:

1. Is the current period interest sufficient to cover the promised coupons: $L_t - B \geq 0$? If *yes*, then the following overcollateralization test must be performed to see how much flows to trust: Is $L_t - B \geq K$? If *yes*, then K is diverted to trust, and $L_t - B - K$ flows to equity holders: $OC_t = K$. If *no*, then $L_t - B$ is diverted to trust, and nothing flows to equity holders: $OC_t = L_t - B$

2. Is the current period interest sufficient to cover the promised coupons: $L_t - B \geq 0$? If *no*, then the interest is not sufficient to pay bondholders and all L_t flows to bondholders. Therefore, the shortfall is $B - L_t$. The next step is to check if the accumulated funds in the spread trust can cover the shortfall. If the trust account has enough funds, the bondholders can be paid in full. If the trust account does not have enough funds, then the bondholders suffer a writedown.

The previous steps outlined the basic procedure for tranche cash flow distribution; however, a few more factors need to be considered. First, for each period there are possible defaults. For simplicity, assume the number of defaults (d_t) is constant for each period. Second, the amount recovered in year t (assuming a 40% recovery rate) equals:

$$R_t = 0.4d_t \times \text{loan amount}$$

Therefore, the total amount deposited into the trust account in year *t* is:

$$R_t + OC_t$$

It follows that the total amount accumulated in the trust account in year *t* is:

$$R_t + OC_t + \sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau$$

Now, if excess spread is negative ($L_t - B < 0$), the custodian must check if the trust account can cover the shortfall. Formally, the test for the custodian is:

$$R_t + \sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau > B - L_t$$

Note that there is no OC_t term to add to R_t since there is no excess spread this period. If the test is true, then the trust account can make the bondholders whole. If it is not true, then the fund is reduced to zero and bondholders receive $R_t + \sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau$ from the trust account.

Using the previous exposition, the amount diverted to the overcollateralization account can be calculated as:

$$OC_t = \begin{Bmatrix} \min(L_t - B, K) \\ \max\left[L_t - B, -\left[\sum_{\tau=1}^{t-1}(1+r)^{t-\tau}OC_\tau + R_t\right]\right] \end{Bmatrix} \text{for} \begin{Bmatrix} L_t \geq B \\ L_t < B \end{Bmatrix}$$

Note that the upper condition represents inflows to the trust account while the lower condition represents outflows from the trust account.

Finally, the equity cash flows can be expressed as:

$$\max(L_t - B - OC_t, 0) \text{ for } t = 1,\ldots,T-1$$

The cash flows in the final year must be examined separately for several reasons. First, the surviving loans reach maturity and principal is returned. Second, there is no diversion to the trust account because the structure ends and all proceeds follow the waterfall. Third, since there is no diversion to the trust, there is no need to test overcollateralization triggers.

The terminal cash flows are summarized as follows:

1. Loan interest = $\left(N - \sum_{t=1}^{T} d_t\right) \times (\text{LIBOR} + \text{spread}) \times \text{par}$
2. Proceeds (par) from redemption of surviving loans = $\left(N - \sum_{t=1}^{T} d_t\right) \times \text{par}$

3. Recovery in final year: $R_T = 0.4d_T \times \text{par}$

4. Residual in trust account: $\sum_{\tau=1}^{T}(1+r)^{t-\tau}OC_t$

The sum of these terminal cash flows is compared to the amount due to the senior tranche. If the sum is large enough, the senior tranche is paid off and the remainder is available for the rest of the capital structure. If the remainder is large enough to cover the junior tranche, then the residual flows to equity. If the remainder cannot meet junior claims, the junior bonds receive the excess and equity holders receive nothing.

As an example, determine the terminal cash flows to senior, junior, and equity tranches given the following information. The original loan pool included 100 loans with $1 million par value and a fixed coupon of 8%. The number of surviving loans is 90. The par for the senior and junior tranches is 75% and 20%, respectively. The equity investors contributed the remaining 5%. There were two defaults with recovery rate of 40% recovered at the end of the period. The value of the trust account at the beginning of the period is $16 million earning 4% per annum.

1. Total size of collateral pool at origination: 100 × $1,000,000 = $100,000,000

2. Senior tranche = $75,000,000
   Junior tranche = $20,000,000
   Equity tranche = $5,000,000

3. Interest from loans: 90 × 8% × $1,000,000 =	$7,200,000
4. Redemption at par: 90 × $1,000,000 =	$90,000,000
5. Recovery in final year: 2 × 40% × $1,000,000 =	$800,000
6. Value of OC at end of final year: $16,000,000 × 1.04 =	<u>$16,640,000</u>
7. Total available to satisfy all claims =	$114,640,000

8. Senior claim = $75,000,000 < $114,640,000. Senior claim is satisfied w/o impairment
9. Junior claim = $20,000,000 < $114,640,000 – $75,000,000 so junior claim is satisfied
10. Equity claim = $114,640,000 – $75,000,000 – $20,000,000 = $19,640,000

Now, continue with the same example, but change the interest rate to 5% and the beginning OC value to $3 million. The first two steps will be the same as before.

3. Interest from loans: 90 × 5% × $1,000,000 =	$4,500,000
4. Redemption at par: 90 × $1,000,000 =	$90,000,000
5. Recovery in final year: 2 × 40% × $1,000,000 =	$800,000
6. Value of OC at end of final year: $3,000,000 × 1.04 =	<u>$3,120,000</u>
7. Total available to satisfy all claims =	$98,420,000

8. Senior claim = $75,000,000 < $98,420,000. Senior claim is satisfied w/o impairment
9. Junior claim = $20,000,000 < $98,420,000 – $75,000,000 so junior claim is satisfied
10. Equity claim = $98,420,000 – $75,000,000 – $20,000,000 = $3,420,000

Finally, continue with the same example, but change the interest rate to 4% and the beginning OC value to $1 million. Assume a recovery rate of zero. Again, the first two steps are the same as before.

3.	Interest from loans: 90 × 4% × $1,000,000 =	$3,600,000
4.	Redemption at par: 90 × $1,000,000 =	$90,000,000
5.	Recovery in final year: 2 × 0% × $1,000,000 =	0
6.	Value of OC at end of final year: $1,000,000 × 1.04 =	$1,040,000
7.	Total available to satisfy all claims =	$94,640,000

8. Senior claim = $75,000,000 < $94,640,000. Senior claim is satisfied w/o impairment
9. Junior claim = $20,000,000 > $94,640,000 – $75,000,000 so junior claim is impaired
   Junior tranche receives $19,640,000
10. Equity claim = $94,640,000 – $75,000,000 – $20,000,000 < 0
    Equity tranche receives $0

Simulation Approach

LO 23.6: Describe a simulation approach to calculating credit losses for different tranches in a securitization.

The prior analysis made a few very important simplifying assumptions. In particular, the analysis assumed that the default rate was constant year over year, each loan exhibited the same default probability, and the correlation between loans was ignored. In practice, these assumptions need to be brought into the analysis and the only tractable way to do so is via simulation.

Although the technical details are well beyond the scope of the exam, we can sketch out the basic steps and intuition for the simulation approach to calculating credit losses.

Step 1: Estimate the parameters.
Step 2: Generate default time simulations.
Step 3: Compute portfolio credit losses.

The first step is to estimate the critical parameters, default intensity, and pairwise correlations. The default intensity can be estimated using market spread data to infer the hazard rate across various maturities. This piecewise-bootstrapping methodology to construct the cumulative default distribution was discussed in Topic 21. Estimating the correlation coefficients is more challenging because of a lack of usable market data. The copula correlation could be useful in theory but suffers empirical precision in practice. Instead, a sensitivity analysis is performed for various default and correlation pairs.

The second step identifies if and when the security defaults. Simulation provides information on the timing for each hypothetical outcome. The third step uses the simulation output to determine the frequency and timing of credit losses. The credit losses can be "lined up" to assess the impact on the capital structure losses. The tail of the distribution will identify the credit VaR for each tranche in the securitization.

Impact of Probability of Default and Default Correlation

LO 23.7: Explain how the default probabilities and default correlations affect the credit risk in a securitization.

There are several important comparative statistics associated with a generic securitization. The following results represent the effect of the average tranche values and writedowns. The implications of extreme tail events will be discussed shortly using VaR. The first factor to consider is the probability of default. It is straightforward to see that, for a given correlation, increasing the probability of default will negatively impact the cash flows and, thus, the values of all tranches.

The effect of changing the correlation is more subtle. Consider the stylized case where the correlation is very low, say zero, so loan performance is independent. Therefore, in a large portfolio, it is virtually impossible for none of the loans to default and it is equally unlikely that there will be a large number of defaults. Rather, the number of defaults should be very close to the probability of default times the number of loans. So, the pool would experience a level of defaults very close to its mathematical expectation and is unlikely to impair the senior tranches. The analogous situation is flipping a coin 1,000 times—the number of heads would be very close to 500. It would be virtually impossible for the number of heads to be less than 400 or greater than 600. Now, if the correlation increases, the default of one credit increases the likelihood of another default. Thus, increasing correlation decreases the value of senior tranches as the pool is now more likely to suffer extreme losses. This effect is exacerbated with a higher default probability.

Now consider the equity tranche. Recall that the equity tranche suffers the first writedowns in the pool. Therefore, a low correlation implies a predictable, but positive, number of defaults. In turn, the equity tranche will assuredly suffer writedowns. On the other hand, if the correlation increases, the behavior of the pool is more extreme, and there may be high levels of related losses or there may be very few loan losses. In sum, the equity tranche increases in value from increasing correlation as the possibility of zero (or few) credit losses increases from the high correlation.

The correlation effect on the mezzanine tranche is more complex. When default rates are low, increasing the correlation increases the likelihood of losses to the junior bonds (similar to senior bonds). However, when default rates are relatively high, increasing the correlation actually decreases the expected losses to mezzanine bonds as the possibility of few defaults is now more likely. Accordingly, the mezzanine bond mimics the return pattern of the equity tranche. In short, increasing correlation at low default rates decreases mezzanine bond values, but at high default rates it will increase mezzanine bond values.

Convexity is also an issue for default rates. For equity investors, as default rates increase from low levels, the equity tranche values decrease rapidly then moderately (a characteristic of positive convexity). Since the equity tranche is thin, small changes in default rates will disproportionately impact bond prices at first. Similarly, senior tranches exhibit negative convexity. As defaults increase, the decline in bond prices increases. As usual, the mezzanine impact is somewhere in between: negative convexity at low default rates, positive convexity at high default rates.

The previous section focused on the average (mean) value of the tranches while this section examines the distribution of possible tranche values (risk). Specifically, the goal is to analyze the impact of default probability and default correlation under extreme conditions (far into the tail). The metric used is credit VaR for various ranges of default probability and default correlation for the senior, junior, and equity tranches. The main result is that increasing default probability, while holding correlation constant, generally decreases the VaR for the equity tranches (less variation in returns) and increases the VaR for the senior tranches (more variation in returns). As usual, the mezzanine effect is mixed: VaR increases at low correlation levels (like senior bonds) then decreases at high correlation levels (like equity). These results are summarized in Figure 3.

Figure 3: Increasing Default Probability (Holding Correlation Constant)

	Mean value	*Credit VaR*
Equity tranche	↓	↓
Mezzanine tranche	↓	↑ then ↓
Senior tranche	↓	↑

The next effect to consider is the impact of a rising correlation. As a reminder, increasing correlation increases the clustering of events, either high frequency of defaults or very low frequency of defaults. Increasing correlation decreases senior bond prices as the subordination is more likely to be breached if defaults do indeed cluster. In contrast, equity returns increase as the low default scenario is more probable relative to low correlation where defaults are almost certain.

As the default correlation approaches one, the equity VaR increases steadily. The interpretation is that although the mean return is increasing so is the risk as the returns are more variable (large losses or very small losses).

All else equal, the senior VaR also increases consistently with correlation. However, we note an interesting effect: the incremental difference between high correlations (0.6 versus 0.9) is relatively small. In addition, two pairwise results are worth highlighting. If correlation is low and default frequency is relatively high, then senior bonds are well insulated. In fact, at the 10% subordination level, the senior bonds would be unaffected even at a high default rate. At the other extreme, when correlations are high (0.6 or above), then the VaRs are quite similar regardless of the default probability. Hence, generally speaking, correlation is a more important risk factor than default probability which may not be entirely intuitive.

The implications for the mezzanine tranche are, again, mixed. When default rates and correlations are lower, the mezzanine tranche behaves more like senior notes with low VaRs. However, when the default probabilities are higher and/or pairwise correlation is high, the risk profile more closely resembles the equity tranche. These results are summarized in Figure 4.

Figure 4: Increasing Correlations (Holding Default Probability Constant)

	Mean value	*Credit VaR*
Equity tranche	↑	↑
Mezzanine tranche	↓(at low default rates) ↑(at high default rates)	↑
Senior tranche	↓	↑

Measuring Default Sensitivities

LO 23.8: Explain how default sensitivities for tranches are measured.

The previous discussion highlighted the effect of increasing the probability of default, which decreases tranche values. However, this effect is not necessarily linear and also depends on the interaction with the default correlation. To analyze the marginal effects in more detail, the definition of DV01 is extended to default probabilities and is called "default '01." The default probability will be shocked up and down by the same amount (by convention 10 basis points) and each tranche will be revalued through the VaR simulations. The formulation for default '01 of each tranche is as follows:

$$1/20\ [(\text{mean value / loss based on } \pi + 0.001) - (\text{mean value / loss based on } \pi - 0.001)]$$

From this equation, there are several qualitative impacts to note. First, the default sensitivities are always positive for any default probability-correlation combination. This follows from the previous observation that all tranches are negatively affected from increasing default probabilities. Second, the default '01 will approach zero as default rates become sufficiently high as the marginal impact of increasing the default rate has minimal effect. The third result follows from the second. There will be more variation in the default sensitivities when the default rate generates losses close to the tranche's attachment point. This result is similar to the high gamma (high sensitivity in delta) for options at-the-money.

Risks for Structured Products

LO 23.9: Describe risk factors that impact structured products.

Aside from the credit portfolio modeling issues discussed before, there are at least three other risks that deserve discussion: systematic risk, tranche thinness, and loan granularity.

Similar to a well-diversified equity portfolio that cannot eliminate systematic risk, the same holds true for credit portfolios. Unfortunately, even when the collateral pool is well-diversified among lenders, terms, geography, and other factors, high systematic risk expressed in high correlations can still severely damage a portfolio. As previously discussed, with increases in pairwise correlations, the likelihood of senior tranche writedowns increases as well.

The equity and mezzanine tranches are relatively thin. This also manifests itself in the relative closeness of the 95% and 99% credit VaR. The implication is that given that the tranche has been breached, the loss is likely very large.

Loan granularity references the loan level diversification. For example, in a collateralized MBS pool, the portfolio composition is a few loans but the loans are of substantial size. This reduction in sample size increases the probability of tail events in relation to an equal sized portfolio constructed with more loans of smaller amounts.

Implied Correlation

LO 23.10: Define implied correlation and describe how it can be measured.

The implied correlation is a very similar concept to the implied volatility of an equity option. For options, the Black-Scholes-Merton model is a widely accepted valuation model and so the observable market price is associated with a unique unobserved volatility. For securitized tranches, the process is exactly the same. Starting with observed market prices and a pricing function for the tranches, it is possible to back out the unique implied correlation to calibrate the model price with the market price.

The mechanical part of the process involves several intermediate steps. First, the observable credit default swap (CDS) term structure is used to extract risk-neutral default probabilities and possibly recovery rates. Assuming constant pairwise correlation and market prices for the respective tranches, the default estimates and correlation estimates can be fed into a copula. The output is the risk-neutral implied correlation (i.e., base correlation) per tranche. The correlation estimates will vary between the tranches and are not likely to be constant giving rise to correlation skew. As an example, suppose the observed market price of the equity tranche increases from $3 million to $3.2 million, but the estimates of the risk-neutral probability of default remain the same. It can be inferred that the market's estimate of the implied correlation must have increased. The precise value must be extracted from the pricing model but qualitatively the direction is correct; increasing correlations benefit equity holders.

Motivations for Using Structured Products

LO 23.11: Identify the motivations for using structured credit products.

Identifying the motivations of loan originators and investors can provide a better understanding for why securitizations are established.

Loan originators, who help create securitizations by selling loans into a trust, are attracted to borrowing via securitization given its ability to provide a lower cost of funding. Without securitization, loans would either be retained or sold in the secondary market. These alternatives would likely be more costly than securing funding via securitization. A lower cost of funding can be obtained given the diversification of the loan pool and the reputation of the originator for underwriting high-quality loans. However, some loan pools, such as commercial mortgage pools, can be difficult to diversify. Thus, an element of systematic risk

may still exist, which could lead to an underestimation of overall risk. An additional benefit of securitization for loan originators is the collection of servicing fees.

Investors, who purchase the assets in a securitization, are attracted to investing in diversified loan pools that they would not otherwise have access to without securitization, such as mortgage loans and auto loans. In addition, the ability to select a desired risk-return level via tranching offers another advantage for investors. Equity tranches will offer higher risk-return levels, while senior tranches will offer lower risk-return levels. However, it is important for investors to conduct the proper due diligence when analyzing potential tranche investments in order to understand the actual level of risk involved.

Key Concepts

LO 23.1

Securitization is the process of pooling cash flow generating assets and reapportioning the cash flows into bonds. These structured products generate a wide range of risk-return profiles that vary in maturity, credit subordination (equity, mezzanine, and senior), type of collateral (mortgages, auto loans, and credit card balances), active or passive management, and static or revolving assets. A true securitization removes the assets from the originator's balance sheet.

LO 23.2

The capital structure of a securitization refers to the different size and priority of the tranches. In general, the senior tranches are the largest, safest, and lowest yielding bonds in the capital structure. The mezzanine tranche has lower priority than the senior tranche and is promised a higher coupon. The lowest priority tranche that bears the first loss is the equity tranche. The size of the equity and mezzanine tranches provides subordination for the senior tranche. Internal credit enhancement, such as overcollateralization and excess spread, buffers the senior tranches from losses. Likewise, external wraps and insurance also protect the senior bondholders.

LO 23.3

A waterfall structure details the distribution of collateral cash flows to the different classes of bondholders. The equity tranche typically receives the residual cash flows once the senior and mezzanine investor claims are satisfied. If the cash flows to equity holders exceed the overcollateralization trigger, the excess is diverted to a trust account. Fees and defaults will reduce the net cash flows available for distribution.

LO 23.4

Securitization is a complicated process and typically involves an originator, underwriter, credit rating agency, servicer, and manager. The originator creates the initial liability; the underwriter pools and structures the terms of the deal as well as markets the issue; the credit rating agency is an active participant suggesting/requiring sufficient subordination and enhancements to justify the ratings; the servicer collects and distributes the cash flows to investors and manages distress resolution; managers, both static and active, usually bear the first loss to mitigate conflict of interest in asset selection and credit monitoring.

LO 23.5

The three-tiered waterfall will have scheduled payments to senior and mezzanine tranches. The equity tranche receives cash flows only if excess spread > 0 (i.e., interest collected > interest owed to senior + mezzanine). The overcollateralization account increases from recovery of defaulted assets and diversion of spread (usually a maximum is predetermined) and earns the money market rate. If excess spread is negative (i.e., interest collected < interest owed to senior + mezzanine), the OC account will use all of its available funds until depleted. The terminal cash flows are more complicated: redemptions at par + interest from surviving loans + recovery in final period + terminal OC account. No funds are diverted in the final year as it all is aggregated and disbursed. Senior claims are paid first; if senior is paid in full, mezzanine claims are paid; if mezzanine is paid in full, the residual accrues to equity holders.

LO 23.6

Simulation is a useful technique to provide more insight into the performance of the collateral and, hence, cash flows to the tranches. In particular, the default intensity can be time-varying and estimated using a hazard distribution. The correlation between loans is critical to the performance of the pool, so various default probability/correlation pairs are used. Copulas could be used to simulate the timing of the defaults. Finally, simulations allow computation of VaRs for each tranche.

LO 23.7

Increasing default probability will decrease all tranches unconditionally. In contrast, increasing correlation will impact each tranche differently. In general, increasing default correlation increases the likelihood of extreme portfolio behavior (very few or many defaults).

Credit VaR can be used to measure the value of the tranches in the left tail. Increasing the correlation increases the VaR of all tranches. In contrast, increasing the probability of default decreases equity VaR and increases senior VaR.

LO 23.8

Default sensitivities are measured analogously to DV01 and spread ‘01 by shocking the default probability up and down by 10 basis points. Default sensitivities are always positive and are largest when the resulting loss is close to the attachment point.

LO 23.9

Similar to equity portfolios, systematic risk is present in credit portfolios. Extreme loss events are captured by high default correlations. The thinness of the equity and mezzanine tranches implies that conditional losses are likely to be large. A less granular pool (fewer but larger loans) is more likely to experience a tail event, all else equal.

LO 23.10

Implied default correlations for each tranche can be backed out of the tranche pricing model similar to how the implied volatility is calculated for the Black-Scholes-Merton model.

LO 23.11

Loan originators help create securitizations by selling loans into a trust. They are attracted to secured borrowing via securitization because it provides a lower cost of funding than alternatives such as retaining loans. Investors purchase the bonds and equity in a securitization. They are attracted to securitization because it allows them to invest in diversified loan pools that are typically reserved for banks.

Concept Checkers

1. How many of the following statements concerning the capital structure in a securitization are most likely correct?

   I. The mezzanine tranche is typically the smallest tranche size.
   II. The mezzanine and equity tranches typically offer fixed coupons.
   III. The senior tranche typically receives the lowest coupon.

   A. No statements are correct.
   B. One statement is correct.
   C. Two statements are correct.
   D. Three statements are correct.

2. Assume there are 100 identical loans with a principal balance of \$500,000 each. Based on a credit analysis, a 300 basis point spread is applied to the borrowers. LIBOR is currently 4% and the coupon rate will reset annually. The senior, junior, and equity tranches are 75%, 20%, and 5% of the pool, respectively. The spreads on the senior and mezzanine tranches are 2% and 6%. Excess cash flow is diverted above \$1,000,000. Assume the default rate is 2%. What are the cash flows to the mezzanine and excess trust account in the first period?

	Mezzanine	Trust account
A.	\$1,000,000	\$0
B.	\$1,000,000	\$180,000
C.	\$2,250,000	\$200,000
D.	\$2,250,000	\$250,000

3. Which of the following participants in the securitization process is least likely to face a conflict of interest?
   A. Credit rating agency and servicer.
   B. Servicer and underwriter.
   C. Custodian and trustee.
   D. Trustee and manager.

4. Which of the following statements about portfolio losses and default correlation are most likely correct?

   I. Increasing default correlation decreases senior tranche values but increases equity tranche values.
   II. At high default rates, increasing default correlation decreases mezzanine bond prices.

   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

5. Which of the following statements best describes the calculation of implied correlation?
   A. The implied correlation for the mezzanine tranche assumes non-constant pairwise correlation.
   B. Observable market prices of credit default swaps are used to infer the tranche values.
   C. The tranche pricing function is calibrated to match the model price with the market price.
   D. The risk-adjusted default probabilities are used in model calibration.

Concept Checker Answers

1. **B** Senior tranches are perceived to be the safest, so they receive the lowest coupon. The equity tranche receives residual cash flows and no explicit coupon. Although the mezzanine tranche is often thin, the equity tranche is typically the thinnest slice.

2. **A** The interest rate on the loans = 4% (LIBOR) + 3% (spread) = 7%. Therefore, the total collateral cash flows in the first period = 100 × \$500,000 × 7% × (1 – 0.02) = \$3,430,000. The senior tranche receives \$50 million × 0.75 × (4% + 2%) = \$2,250,000. Similarly, the mezzanine tranche receives \$50 million × 0.20 × (4% + 6%) = \$1,000,000. Next, the residual cash flows are calculated: \$3,430,000 – \$2,250,000 – \$1,000,000 = \$180,000. Since \$180,000 < \$1,000,000, all cash flows are claimed by the equity investors and there is no diversion to the trust account.

3. **C** The custodian and trustee play the least important roles in the securitization process. The servicer, originator, underwriter, credit rating agency, and manager all face conflicts of interest to varying degrees.

4. **A** Statement I is true. Increasing default correlation increases the likelihood of more extreme portfolio returns (very high or very low number of defaults). The increased likelihood of high defaults negatively impacts the senior tranche. On the other hand, the increased likelihood of few defaults benefits the equity tranche as it bears first loss. Statement II is false. At high default rates, increasing the correlation increases the likelihood of more extreme portfolio returns which benefits equity investors and mezzanine investors.

5. **C** Starting with observed market prices and a pricing function for the tranches, it is possible to back out the implied correlation to calibrate the model price with the market price. The computation of implied correlation assumes constant pairwise correlation. Both credit default swap and tranche values are observed. Observed tranche values are used in conjunction with risk-neutral default probabilities to compute implied correlation.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Counterparty Risk

Topic 24

Exam Focus

This topic examines the concept of counterparty credit risk and introduces techniques for mitigating and managing counterparty risk. For the exam, know the basic terminology related to counterparty risk and the definitions and differences among the various credit exposure metrics that are discussed. Also, be familiar with the types of institutions that take on counterparty risk through trading, and have an understanding of how institutions can mitigate and manage this risk.

Counterparty Risk and Lending Risk

LO 24.1: Describe counterparty risk and differentiate it from lending risk.

Counterparty risk is the risk that a counterparty is unable or unwilling to live up to its contractual obligations (i.e., counterparty defaults). Within the context of derivatives contracts, default occurs at some point after inception but prior to the end of the contract term (i.e., presettlement). If default occurs, current and future payments required by the contract will not be made.

Lending risk has two notable characteristics: (1) the principal amount at risk is usually known with reasonable certainty (e.g., mortgage at a fixed rate) and (2) only one party (unilateral) takes on risk.

Counterparty risk goes further than lending risk because it takes into account that the value of the underlying instrument is uncertain in terms of absolute amount and in terms of which party will have a subsequent gain or loss. In addition, counterparty risk is bilateral in that each party takes on the risk that the counterparty will default; the party that is "winning" takes on the risk that the party that is "losing" will default.

Professor's Note: Counterparty risk is typically used to refer to risk that occurs prior to settlement (i.e., presettlement risk). However, the term may occasionally be used with regard to settlement risk, which is the risk stemming from the fact that there may be a difference in timing between when each counterparty performs its contractual obligations at settlement. During this period, default can occur, resulting in a large loss for one party as credit exposure is at its highest level during the settlement process. If not specifically defined, assume counterparty risk refers exclusively to presettlement risk.

Transactions With Counterparty Risk

LO 24.2: Describe transactions that carry counterparty risk and explain how counterparty risk can arise in each transaction.

Exchange-traded derivatives do not carry counterparty risk because the exchange is usually the counterparty. Therefore, the focus of this topic will be on securities financing transactions and over-the-counter (OTC) derivatives.

Securities financing transactions include repos and reverse repos, and securities borrowing and lending.

Repos are short-term lending agreements (as short as one day) secured by collateral. The agreement involves a party (the seller or borrower) selling securities to another party (the buyer or lender) for cash, with the seller/borrower buying back the securities at a later date. The lender receives the repo rate, calculated as a risk-free interest charge, plus a counterparty risk charge. Collateral is usually in the form of liquid securities. A haircut is applied to mitigate against the counterparty risk that the borrower will not repay the cash and to mitigate against a decline in the value of the collateral. To illustrate the use of a haircut, assume a 2% haircut on a $100 million loan amount. This means that approximately $102.04 million of securities is required as collateral on a $100 million loan [$100 million / (1 – 0.02) = $102.04 million].

Although reduced by collateral on the loan, counterparty risk still exists in both a repo transaction and a reverse repo transaction (which is a repo, from the perspective of the other party) due to the fact that the seller may fail to repurchase the security at the maturity date (forcing the buyer to liquidate the collateral to recover the cash that was loaned). If securities are used as collateral, risk exists that the market value of the securities will have declined prior to maturity.

Securities borrowing and lending are repos, just with securities involved rather than cash. The associated counterparty risk is similar to that of repos.

OTC derivatives include interest rate swaps (the bulk of the transactions), foreign exchange transactions, and credit default swaps (CDSs).

When comparing an interest rate swap to a regular loan, counterparty risk is reduced for the interest rate swap because there is no exchange of principal. The risk lies in the exchange of floating cash payments versus fixed cash payments. The notion of "netting" further reduces counterparty risk because only the difference between the two payments (the net amount) is exchanged periodically. As soon as the counterparty defaults on payments, there is no need for the other party to continue making payments.

Foreign exchange forwards carry large counterparty risk due to the need to exchange notional amounts and due to long maturities (thereby increasing the probability that a default will occur at least once).

Credit default swaps carry large counterparty risks due to wrong-way risk and significant volatility (thereby increasing the probability that there will be a "losing" party that will

default). Wrong-way risk refers to an increase in exposure when counterparty credit quality worsens. It can be illustrated in a very simplified example whereby a firm invested in Greek sovereign debt wishes to protect its position by purchasing a CDS on Greek sovereign debt from a Greek bank. Assuming a reduction in the rating of Greek sovereign debt, the buyer of the CDS is "winning." However, the ability of the "losing" counterparty (the Greek bank) to meet its obligations will further be impaired as a result of the credit rating decrease.

Institutions That Take on Counterparty Risk

LO 24.3: Identify and describe institutions that take on significant counterparty risk.

The institutions that take on counterparty risk through trading activities vary in size, volume, coverage of asset classes, and their willingness (and ability) to post collateral against their positions. At a high level, these institutions (called "derivatives players" in this context) fall into three categories: large, medium, and small.

Large derivatives players are large banks (dealers) that trade with each other and with a large number of clients. They tend to have high numbers of OTC derivatives on their books and cover a very wide range of assets, including commodities, equity, foreign exchange, interest rate, and credit derivatives. In addition, they will post collateral against their positions.

Medium derivatives players are often smaller banks or financial institutions that also have a large number of clients and conduct a high volume of OTC derivatives trades. While they also cover a wide range of assets, they are not as active in all of them as large players. In addition, it is likely (but not definite) that they will post collateral against positions.

Small derivatives players are sovereign entities, large corporations, or smaller financial institutions with specific derivatives requirements that determine the trades they undertake. Trades are done with only a small number of counterparties, and, as expected, they have few OTC derivatives trades on their books. Unlike large and medium players, small players are likely to specialize in just one asset class. They will also differ from larger players in terms of collateral, which if posted will often be illiquid.

While the entities described here take on counterparty risk through trading activity, third parties exist that offer products and services used by market participants to reduce counterparty risks and improve efficiency. These products and services include clearing services, software, trade compression, and collateral management.

Counterparty Risk Terminology

LO 24.4: Describe credit exposure, credit migration, recovery, mark-to-market, replacement cost, default probability, loss given default, and the recovery rate.

Credit exposure (or simply *exposure*) is the loss that is "conditional" on the counterparty defaulting. It can be illustrated with a financial instrument contract between two parties. After inception, assume Counterparty A has a positive value (it is the creditor and is owed money), and Counterparty B has a negative value (it is the debtor and owes money). If Counterparty B defaults, Counterparty A will suffer a loss on the amount owed.

In quantifying exposure, it is not always the case that the full principal amount is at risk. Therefore, a more relevant calculation is replacement cost, together with an assumption of a zero recovery value. Furthermore, calculations must consider current exposure (current claims and commitments), future exposure (potential future claims), and contingent liabilities.

Regarding **credit migration**, the counterparty may default or its credit rating may deteriorate over the term of the contract, especially for long-time horizons. Alternatively, there may be an improvement in credit rating over time. To assess credit migration, we must consider the term structure of **default probability**:

- Future default probability will likely decrease over time, especially for periods far into the future. This is due to the higher likelihood that the default will have already occurred at some earlier point.
- An expected deterioration in credit quality suggests an increasing probability of default over time.
- An expected improvement in credit quality suggests a decreasing probability of default over time.

Empirically, there is mean reversion in credit quality, so the implication is that counterparties with strong credit ratings tend to deteriorate (increasing default probability over time), and those with weak credit ratings tend to improve (more likely to default earlier and less likely later). Default probability of a counterparty can be computed in two ways: a real (historical) measure (identifying the actual default probability) and a risk-neutral measure (computing the theoretical market-implied probability).

Recovery is measured by the recovery rate, which is the portion of the outstanding claim actually recovered after default. For example, a recovery rate of 70% suggests a 30% loss. As discussed earlier in the definition of exposure, recovery is not usually considered when pricing credit risk. Related to the concept of recovery is **loss given default** (LGD), which is calculated as 1 – recovery rate.

Mark to market (MtM) is an accrual accounting measure that is equal to the sum of the MtM values of all contracts with a given counterparty. Although in theory it represents the current potential loss, it fails to consider other factors such as netting, collateral, or hedging. MtM is equal to the present value of all expected inflows less the present value of expected payments (positive if in favor of the party and negative if not). MtM is a measure of replacement cost. However, although generally close, current **replacement cost** is not theoretically the same as the MtM value due to factors such as transaction costs and bid-ask spreads.

Managing, Mitigating, and Quantifying Counterparty Risk

LO 24.5:Identify and describe the different ways institutions can quantify, manage and mitigate counterparty risk.

Managing Counterparty Risk

Methods to manage counterparty risk include the following: trading only with high-quality counterparties, cross-product netting, close-out, collateralization, walkaway features, diversifying counterparty risk, and exchanges and centralized clearinghouses.

Trading only with **high-quality counterparties** is a simple and straightforward method for managing counterparty risk. All of these counterparties would have AAA credit ratings and may not be required to provide collateral.

Cross-product netting works with derivative transactions that can have both a positive and a negative value. In the case of a default by either counterparty, a netting agreement will allow transactions to be aggregated and reduce the risk for both parties. The legal and operational risks that accompany netting must be considered. For example, legal risk materializes if a netting agreement is found to be legally unenforceable. An example of cross-product netting is as follows (from Counterparty A's perspective):

	Counterparty A	*Counterparty B*
Trades with positive MtM	+\$20 million	–\$20 million
Trades with negative MtM	–\$17 million	+\$17 million
Exposure with no netting	+\$20 million	+\$17 million
Exposure with netting	+\$3 million	\$0

Close-out is the immediate closing of all contracts with the defaulted counterparty. When combined with netting of MtM values, an institution may offset what it owes to the counterparty (a negative amount) against what it is owed by the counterparty (a positive amount). If the net amount is negative, the institution will make a payment, but if the net amount is positive, it will make a claim. This results in an immediate realization of net gains or losses for the institution.

Collateralization (i.e., margining) occurs in the form of a collateral agreement between two counterparties that reduces exposure by requiring sufficient collateral to be posted by either counterparty to support the net exposure between them. Sufficient collateral does theoretically reduce the net exposure to zero. Posting collateral is done on a periodic basis to minimize transaction costs. However, collateralization does come with market, operational, and legal risks as well as significant work requirements to ensure the process is done properly.

A **walkaway feature** allows a party to cancel the transaction if the counterparty defaults. It is advantageous if a party has a negative MtM and the counterparty defaults.

Diversification of counterparty risk limits credit exposure to any given counterparty consistent with the default probability of the counterparty. When an institution trades with more counterparties, there is much less exposure to the failure of any given counterparty.

As described previously, exchanges and centralized clearinghouses take on the role of the counterparty and guarantee all trades by removing all counterparty risk from trades. However, this may simply redistribute counterparty risk as opposed to completely eliminating the risk.

Mitigating Counterparty Risk

As mentioned, **netting** is commonly used to mitigate counterparty risk. Each party's required payment is computed and then offset so that only the party that "owes" a net amount is required to make that payment to the counterparty. The success of netting depends on the nature of the payments involved and whether they are easy to offset.

A second way to mitigate counterparty risk is the use of **collateralization**. Taking collateral equal to or greater than the notional amount of principal should theoretically eliminate all counterparty risk. However, by taking collateral, there are some administrative costs involved in addition to taking on liquidity risk (i.e., collateral may have to be sold at a significant discount in the short term) and legal risk (i.e., attempting to take title on the collateral may be a long and drawn out legal process).

A third way to mitigate counterparty risk is through **hedging**. Using credit derivatives allows an organization to reduce counterparty exposure to its own clients in exchange for increasing counterparty exposure to clients of a competitor. Therefore, hedging generates market risk.

Central counterparties (e.g., exchanges and clearinghouses) frequently take on the role of the counterparty, which offers another way to mitigate counterparty risk. They are a convenient way to centralize counterparty risks, settle transactions, and reduce the bilateral risks inherent in many derivatives contracts. However, the use of central counterparties does reduce the incentive of parties to carefully assess and monitor counterparty risks. Therefore, using central counterparties generates operational, liquidity, and systemic risks.

Quantifying Counterparty Risk

In general, counterparty risk for a given transaction is quantified on the following levels:

- *Trade level*: considers the nature of the trade and related risk factors.
- *Counterparty level*: takes into account risk mitigating factors such as netting and collateral for each individual counterparty.
- *Portfolio level*: considers overall counterparty risk in that only a small percentage will likely default in a given time period.

Within the context of derivatives pricing, there is a portion that assumes no counterparty risk and a portion that accounts for counterparty risk. The portion that accounts for counterparty risk is known as the **credit value adjustment** (CVA). A trader's objective is to earn a return greater than the CVA.

The CVA is a complex calculation that takes into account the following elements:

- Default probability of the party itself.
- Default probability of the counterparty.
- Nature of the transaction.
- Netting of existing transactions with the same counterparty.
- Any existing collateralization.
- Any existing hedging positions.

Professor's Note: The credit value adjustment calculation will be examined in Topic 30.

Key Concepts

LO 24.1

Counterparty risk is the risk that a counterparty is unable or unwilling to live up to its contractual obligations. Counterparty risk is different than lending risk because the future value of the contract is highly uncertain; for lending risk, the value is quite certain. In addition, counterparty risk is bilateral, whereas lending risk is unilateral.

LO 24.2

Securities financing transactions, such as securities borrowing and lending and repos and reverse repos, carry counterparty risk. Over-the-counter (OTC) derivatives such as interest rate swaps, foreign exchange forwards, and credit default swaps also carry counterparty risk.

LO 24.3

Institutions that take on counterparty risk through trading activities fall into three size categories: large, medium, and small. They vary based on the volume of trades, coverage of asset classes, and their willingness and ability to post collateral.

LO 24.4

Important terminology relating to counterparty risk includes the following: credit exposure, credit migration, recovery, mark-to-market (MtM), replacement cost, default probability, recovery rate, and loss given default.

LO 24.5

Methods to manage counterparty risk include the following: trading only with high-quality counterparties, cross-product netting, close-out, collateralization, walkaway features, diversifying counterparty risk, and exchanges and centralized clearing houses.

Netting, collateralization, hedging, and central counterparties are some common ways to mitigate counterparty risk.

Counterparty risk is quantified at the trade, counterparty, and portfolio levels. Within the context of the pricing of a derivative, there is a portion that assumes no counterparty risk and a portion to account for counterparty risk. The latter portion is the CVA.

Concept Checkers

1. When considering counterparty credit risk, which of the following financial products has the largest outstanding notional amount in the marketplace?
   A. Credit default swaps.
   B. Foreign exchange forwards.
   C. Interest rate swaps.
   D. Repos and reverse repos.

2. Liz Parker is a junior quantitative analyst who is preparing a report dealing with credit migration. An excerpt of her report contains the following statements:
   I. Future default probability will likely increase over time, especially for periods far into the future.
   II. When computing the default probability of a counterparty under a risk-neutral measure, we need to first determine the actual default probability.

   Which of Parker's statements is (are) correct?
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. Ondine Financial, Inc., (Ondine) uses a variety of techniques to manage counterparty risk. It has entered into an interest rate swap with Scarbo, Inc. (Scarbo). Currently, Ondine's position in the swap has a –$1 million mark-to-market value. Based on the information provided, which of the following credit risk mitigation techniques would be most advantageous to Ondine if Scarbo defaults?
   A. Close-out.
   B. Collateralization.
   C. Netting.
   D. Walkaway.

4. Which of the following statements regarding counterparty credit risk is most accurate?
   A. Counterparty risk is unilateral.
   B. Over-the-counter (OTC) derivatives contain less counterparty risk than exchange-traded derivatives because the counterparty is known.
   C. The precise future value of the contract is uncertain, but the counterparties are aware of whether the future value will be positive or negative.
   D. Counterparty risk is typically associated with counterparty default prior to the settlement rather than default during the settlement process.

5. Which of the following methods of mitigating counterparty risk is most likely to generate systemic risk?
   A. Netting
   B. Collateral.
   C. Hedging.
   D. Central counterparties.

Concept Checker Answers

1. **C** There are two classes of financial products where counterparty risk exists: over-the-counter (OTC) derivatives and securities financing transactions such as repos and reverse repos. OTC derivatives are significantly larger with interest rate swaps comprising the bulk of the market.

2. **D** Future default probability will likely decrease over time, especially for periods far into the future. This is because of the higher likelihood that the default will have already occurred at some earlier point. In computing the default probability of a counterparty under a risk-neutral measure, one needs to compute the theoretical market-implied probability; the actual default probability applies under a real (historical) measure.

3. **D** Because Ondine currently has a negative mark-to-market value and the counterparty is defaulting, Ondine is able to cancel the transaction while it is "losing." Netting and close-out would require Ondine to make a payment because it would owe a net amount of $1 million. Collateralization is not relevant in this scenario.

4. **D** Counterparty risk is a bilateral risk in that both parties are unaware of the eventual value of the contract and they do not know whether they will earn a profit or loss. For exchange-traded derivatives, the counterparty is the exchange, which effectively mitigates counterparty risk. While counterparty default can happen presettlement and during settlement, counterparty risk typically applies to the risk of default prior to settlement.

5. **D** Mitigating counterparty risk often leads to the generation of other types of risk. In the case of central counterparties, systemic risk is created as counterparty risk has been centralized with a limited amount of groups. If one of these groups fails, a substantial shock may be experienced by the financial system as a whole.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Netting, Close-out and Related Aspects

Topic 25

Exam Focus

In this topic, we further discuss ways to mitigate counterparty risk and credit exposure. Specifically, we will address the different methods of reducing current and potential future credit exposure. These methods include termination features and netting and close-out features. For the exam, understand the advantages and disadvantages of netting and termination features. Also, be able to explain reset agreements, break clauses, walkaway clauses, and trade compression and how they are used.

ISDA Master Agreement

LO 25.1: Explain the purpose of an ISDA master agreement.

The International Swaps and Derivatives Association (ISDA) Master Agreement standardizes over-the-counter (OTC) agreements to reduce legal uncertainty and mitigate credit risk. This is accomplished by creating a framework that specifies OTC agreement terms and conditions related to collateral, netting, and termination events. The Master Agreement can cover multiple transactions by forming a single legal contract with an indefinite term.

Netting and Close-Out Procedures

LO 25.2: Summarize netting and close-out procedures (including multilateral netting), explain their advantages and disadvantages, and describe how they fit into the framework of the ISDA master agreement.

Netting and Close-Out Between Two Counterparties

Netting, often called set-off, generally refers to combining the cash flows from different contracts with a counterparty into a single net amount. This is referred to as **payment netting**, which acts to reduce settlement risk while enhancing operational efficiency. A related concept is **close-out netting**, which refers to the netting of contract values with a counterparty in the event of the counterparty's default. The concepts of both netting and close-out incorporate two related rights under a single contract: (1) the right to terminate contracts unilaterally (by only one side) under certain conditions (close-out) and (2) the right to offset (net) amounts due at termination into a single sum.

Before we examine close-out closer, it is important to discuss netting in more detail. Netting has enabled an explosive growth in credit exposures and notional values of trades, and it now covers most derivatives transactions. Institutions often have multiple trades with a counterparty, and these trades can constitute hedges whose values move in opposite directions, or they may constitute unwinds where a reverse trade of equal and opposite value has been executed with the same counterparty. Without netting, an entity's exposure of two equal and opposite trades is the positive mark-to-market exposure. For example, if an entity has two equal and opposite trades with a counterparty with mark-to-market values of +10 and –10, without netting the total exposure is +10. This means that if the counterparty defaults, the value of the two trades is not netted, with the surviving entity having to make a settlement under the negative mark-to-market trade, while unable to collect on the positive one. Therefore, without netting, overall exposure is additive as the sum of the positive mark-to-market values. With netting, exposures of trades are not additive, which significantly reduces risk.

Netting has several advantages and disadvantages:

- *Exposure reduction*: By offsetting exposures with parties managing net positions only, netting reduces risk and improves operational efficiency. Nevertheless, netted exposures can be volatile, which may result in difficulty in controlling exposure.
- *Unwinding positions*: If an entity wishes to exit a less liquid OTC trade with one counterparty by entering into an offsetting position with another counterparty, the entity will remove market risk; however, it will be exposed to counterparty and operational risk. Netting removes these risks through executing a reverse position with the initial counterparty, removing both market and counterparty risk. The downside is that the initial counterparty, knowing that the entity is looking to exit a trade, may impose less favorable terms for the offsetting transaction.
- *Multiple positions*: An entity can reduce counterparty risk, obtain favorable trade terms, and reduce collateral requirements by trading multiple positions with the same counterparty.
- *Stability*: Without netting, entities trading with insolvent or troubled counterparties would be motivated to cease trading and terminate existing contracts, exacerbating the financial distress of the counterparty. With netting, this risk is significantly reduced, and an agreement with a troubled counterparty is more achievable.

Netting agreements (specifically close-out netting) are legal agreements that become effective in the event of a counterparty's bankruptcy. As mentioned, netting agreements are often governed by the ISDA Master Agreement, which serves to eliminate legal uncertainties and reduce counterparty risk under a single legal contract with an indefinite term. A single universal agreement also helps avoid problems that may arise from different treatments of bankruptcy in different jurisdictions. For example, ISDA has obtained legal opinions for the Master Agreement in most jurisdictions. Agreements often cover bilateral netting, which is used for OTC derivative and repo transactions, and balance sheet loans and deposits. When no legal agreement exists that allows netting, exposures do not offset each other and are considered additive.

Close-out and netting become advantageous in derivatives transactions following the default of a counterparty when cash flows cease because these rights allow an entity to execute new replacement contracts. It is clear then that close-out arrangements protect the solvent, or surviving, entity. Note that close-out differs from an **acceleration clause**, which allows the creditor to accelerate (i.e., make immediately due) future payments given a credit event,

such as a ratings downgrade. In contrast to acceleration, **close-out clauses** allow all contracts between a solvent and insolvent entity to be terminated, which effectively cancels the contracts and creates a claim for compensation. If the solvent entity has a negative mark-to-market exposure (it owes the insolvent entity), then the full payment is made to the insolvent entity. If the mark-to-market exposure is positive, the solvent entity becomes a creditor for that amount and can terminate and replace the contracts with another entity.

Both acceleration and close-out clauses have been criticized for making a debtor's refinancing more difficult. Both clauses cause payment amounts to be immediately due and may speed up the financial distress of the insolvent entity. For this reason, courts may impose a stay (temporary suspension) on the agreements to allow for a short period of "time out" while maintaining the validity of the termination clauses.

Despite these criticisms, close-out clauses can be very advantageous to parties. Close-out limits the uncertainty in the value of an entity's position with an insolvent counterparty. Without close-out, an entity would have difficulty estimating to what degree positions offset each other because recovery of exposure is not known. With close-out, however, the solvent entity can fully re-hedge transactions with the insolvent entity while waiting to receive a claim. As a result, although the solvent entity may experience some risk loss, it would minimize market risk and trading uncertainty. In addition, close-out allows entities to freeze their exposures. Because these exposure amounts are known and will not fluctuate, the solvent entity can then better hedge this exposure.

Netting and Close-Out Between Multiple Counterparties

Up until this point, we have been discussing **bilateral netting**; that is, netting arrangements between two entities. Bilateral netting is important in reducing credit exposure; however, it is limited to two entities only. In reality, trades are often structured in a way where an entity trades with multiple counterparties (known as **multilateral netting**). For example, entity A can have exposure to B, entity B has the same exposure to entity C, and entity C has an identical exposure to entity A. The default of any of these entities would give rise to questions on how to allocate losses.

Under multilateral netting, netting arrangements would involve multiple counterparties to mitigate counterparty and operational risk. Typically, multilateral netting is achieved with a central entity, such as an exchange or clearinghouse, handling the netting process, including valuation, settlement, and collateralization. A disadvantage, however, is that this type of netting arrangement mutualizes counterparty risk and results in less incentive for entities to monitor each other's credit qualities. In addition, multilateral netting can enable redundant trading positions to accumulate in the system, resulting in higher operational costs (this risk is reduced by firms that use algorithms to detect and reduce redundant positions). Finally, multilateral netting requires trading disclosure, which may be disadvantageous to firms wishing to keep proprietary information confidential.

Netting Effectiveness

LO 25.3: Describe the effectiveness of netting in reducing credit exposure under various scenarios.

As we have previously discussed, netting can either reduce exposure to a counterparty or have no effect on exposure, but it can never increase it. We now look at netting in more detail, including the relationship between netting and exposure.

A trading instrument will have a beneficial effect on netting if it can have a negative mark-to-market (MtM) value during its life. For instruments whose MtM value can only be positive during their life, the effect on netting will not be as beneficial. Instruments with only positive MtM values include options with up-front premiums such as equity options, as well as swaptions, caps and floors, and FX options. Other instruments can have negative MtM value during their life; however, there is a greater likelihood that MtM will be positive. These instruments include long options without up-front premiums, certain interest rate swaps, certain FX forwards, cross-currency swaps, off-market instruments, and wrong-way instruments.

Despite these instruments having either only positive or mostly positive MtM values, it may still be worthwhile for an entity to include them under a netting agreement for the following reasons:

- Future trades with negative MtM values could offset the positive MtM of these instruments.
- Inclusion of all trades is necessary for effective collateralization.
- Netting is beneficial as it ensures that if these positions need to be unwound in the future and an offsetting (mirror) trade is required, there will be no residual counterparty risk.

Termination Features

LO 25.4: Describe the mechanics of termination provisions and trade compressions and explain their advantages and disadvantages.

LO 25.5: Identify and describe termination events and discuss their potential effects on parties to a transaction.

Termination events allow institutions to terminate a trade before their counterparties become bankrupt. A **reset agreement** readjusts parameters for trades that are heavily in the money by resetting the trade to be at the money. Reset dates are typically linked with payment dates, but they could also be triggered after a certain market value is breached. As an example, consider a resettable cross-currency swap. With this trade, the MtM value of the swap is exchanged at each reset date. In addition, the foreign exchange rate, which influences the swap's MtM value, is reset to the current spot rate. This reset will end up changing the notional amount for one leg of the swap.

Additional termination events (ATEs), which are sometimes referred to as break clauses, are another form of a termination event, which allow an institution to terminate a trade if the creditworthiness of their counterparty declines to the point of bankruptcy. More specifically,

a **break clause** (also called a liquidity put or early termination option) allows a party to terminate a transaction at specified future dates at its replacement value. Break clauses are often bilateral, allowing either party to terminate a transaction, and are useful in providing an option to terminate transactions—particularly long-dated trades—without cost when the quality of the counterparty declines. Events to trigger a break clause generally fall into three categories:

- Mandatory. The transaction will terminate at the date of the break clause.
- Optional. One or both counterparties have the option to terminate the transaction at the pre-specified date.
- Trigger-based. A trigger, like a ratings downgrade, must occur before the break clause may be exercised.

Despite their advantages, break clauses have not been highly popular. One explanation is that break clauses, in effect, represent a discrete form of collateralization; however, collateralization can be better achieved by the continuous posting of collateral. Another explanation is known as "banker's paradox," which implies that for a break clause to be truly useful, it should be exercised early on, prior to the substantial decline in a counterparty's credit quality. Entities, however, typically avoid early exercise to preserve their good relationships with counterparties.

Walkaway clauses allow an entity to benefit from the default of a counterparty. Specifically, under these clauses an entity can walk away from, or avoid, its net liabilities to a counterparty that is in default, while still being able to claim in the event of a positive MtM exposure. Walkaway clauses were popular prior to 1992, but they have been less common since the 1992 ISDA Master Agreement. They have also been criticized for creating additional costs for a counterparty in the event of a default, for creating moral hazard, and, because a walkaway feature may already be priced in a transaction, hiding some of the risks in a transaction. For these reasons, these clauses should be ultimately avoided.

As mentioned previously, multilateral netting is achieved with a central entity, such as an exchange or clearinghouse, handling the netting process, including valuation, settlement, and collateralization. An approach for utilizing multilateral netting without the need for a membership organization is **trade compression**. Because portfolios often have redundancies among trades with multiple counterparties, compression aims to reduce the gross notional amount and the number of trades (e.g., OTC derivatives transactions). Thus, trade compression can reduce net exposure without the need to change an institution's overall risk profile.

Trade compression requires participants to submit applicable trades for compression along with their desired risk tolerance. The submitted trades are then matched to each counterparty and netted into a single contract. For example, consider an institution with three credit default swap (CDS) contracts for the same reference entity and maturity, but with different counterparties. In this case, the three trades can be compressed into a single net contract by netting out the long and short contracts and using the weighted average of the three contract coupons as the net contract coupon. Trade compression services, such as TriOptima, help reduce OTC derivatives exposures for various credit derivatives. In addition, recent changes to the CDS market, such as standard coupons and maturity dates, also help promote the benefits of trade compression.

Key Concepts

LO 25.1

Standardization of terms of OTC derivatives through the ISDA Master Agreement is a key way to mitigate credit risk to improve liquidity and reduce transaction costs.

LO 25.2

Netting involves combining the cash flows from different contracts with a counterparty into a single net amount (payment netting). Close-out netting refers to netting contract values with a counterparty if the counterparty defaults. Without netting, exposures are additive; with netting, exposures of trades are not additive.

Bilateral netting is limited to two entities only. Multilateral netting involves netting between multiple parties, usually with a central entity, such as an exchange or clearinghouse, handling the netting process.

LO 25.3

Netting arrangements are beneficial as long as trading instruments can have negative mark-to-market (MtM) values during their life. Netting for trades with the possibility of only positive exposures is generally not beneficial, although benefits can arise if future trades with negative MtM values could offset the positive MtM of these instruments.

LO 25.4

Walkaway clauses allow an entity to walk away from its liabilities to a counterparty that is in default, while still being able to make a claim on its own exposure. Trade compression reduces net exposure without the need to change the overall risk profile.

LO 25.5

Termination events allow institutions to terminate a trade before their counterparties become bankrupt. A break clause allows a party to terminate a trade at specified future dates at replacement values.

Concept Checkers

1. Riggs Resources, LLC, (Riggs) is a commodity trading firm. Riggs has numerous trades outstanding with several counterparties; however, it is concerned with presettlement risk. In order to reduce presettlement risk (the risk that Riggs's counterparties would default before settlement), it would be most beneficial for Riggs to:
   A. have payment netting.
   B. have close-out netting.
   C. analyze potential losses as the sum of exposures.
   D. have netting but not set-off.

2. Entity XYZ is netting its trades with Entity ABC. Which of the following techniques best describe this type of netting arrangement?
   A. Multilateral netting.
   B. Bilateral netting.
   C. Close-out netting.
   D. Additive exposure netting.

3. Assume the following current MtM values for five different transactions for Entity ABC: +5, –4, +2, +3, and –6. What is the total exposure with and without netting, respectively?
   A. 0, 10.
   B. 20, 10.
   C. 10, 0.
   D. 10, 20.

4. Which of the following trading instruments would have the most beneficial effect on netting?
   A. Options with up-front premiums.
   B. Equity options.
   C. FX options.
   D. Futures.

5. Leverage, Inc., an investment bank, has numerous credit default swaps with XYZ Corp. Leverage has established a break clause with XYZ Corp. to reduce risk. The break clause is trigger-based and may be exercised once the trigger is satisfied. The CEO of Leverage is concerned about a banker's paradox. Which of the following statements best describe the CEO's concern?
   A. To be effective, the break clause option should not be used too early.
   B. The weak firm often recovers after the use of the break clause.
   C. The break clause option is used too late, and the weak firm gets weaker.
   D. The break clause option is used too early, and relations with the counterparty suffer.

Concept Checker Answers

1. **B** To minimize presettlement risk, Riggs should have close-out netting. Under close-out, contracts between solvent and insolvent counterparties are terminated and netted.

   Payment netting would reduce settlement and operational risk, but not presettlement risk. Netting also means individual positive exposures are nonadditive. The terms netting and set-off are synonymous.

2. **B** Bilateral netting is a netting arrangement between two entities and is limited to two entities. Trades with multiple counterparties is known as multilateral netting. Close-out netting refers to netting contract values with a counterparty if the counterparty defaults.

3. **A** The total exposure with netting is 0 ($5 - 4 + 2 + 3 - 6 = 0$), and the total exposure without netting is 10 ($5 + 2 + 3 = 10$).

4. **D** A trading instrument will have a beneficial effect on netting if it can have a negative mark-to-market (MtM) value during its life. For instruments whose MtM value can only be positive during their life, the effect on netting will not be as beneficial. Instruments with only positive MtM values include options with up-front premiums such as equity options, as well as swaptions, caps and floors, and FX options. Futures can have negative MtM values.

5. **C** A break clause (also called a liquidity put or early termination option) allows a party to terminate a transaction at specified future dates at its replacement value. Despite their advantages, break clauses have not been highly popular. One explanation is known as banker's paradox, which implies that for a break clause to be truly useful, it should be exercised early on, prior to the substantial decline in a counterparty's credit quality. Entities, however, typically avoid early exercise to preserve their good relationships with counterparties.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Collateral

Topic 26

Exam Focus

This topic examines collateral and introduces the types of collateral, the features of a collateralization agreement and a credit support annex (one-way and two-way), and the reconciliation of collateral disputes. For the exam, be familiar with the key parameters associated with collateral (e.g., threshold, initial margin, and minimum transfer amount). In addition, understand the risks associated with collateralization, focusing on market risk, operational risk, and funding liquidity risk.

Collateral Management

LO 26.1: Describe the rationale for collateral management.

LO 26.2: Describe the terms of a collateral agreement and features of a credit support annex (CSA) within the ISDA Master Agreement including threshold, initial margin, minimum transfer amount and rounding, haircuts, credit quality, and credit support amount.

The concept behind collateralization is straightforward. When two parties execute certain trades (e.g., OTC forwards, swaps), one will have a negative MtM (mark-to-market) exposure, and the other party will have a positive MtM exposure at any given time. The party with the negative exposure will then post collateral in the form of cash or securities to the party with the positive exposure. In essence, *collateral is an asset supporting a risk in a legally enforceable way*. **Collateral management** is often bilateral, where either side to a transaction is required to post or return collateral to the side with the positive exposure.

Firms can manage credit exposures and mitigate counterparty credit risk by either limiting the notional value of trades with counterparties or offsetting trades that limit exposure though netting. There are essentially four motivations for managing collateral: (1) reduce credit exposure to enable more trading, (2) have the ability to trade with a counterparty (e.g., restrictions on credit ratings may preclude an entity from trading on an uncollateralized basis), (3) reduce capital requirements, and (4) allow for more competitive pricing of counterparty risk.

Collateral management has evolved over the last few decades from having no legal standards to being highly standardized through the introduction of ISDA documentation in 1994. The purpose of a **credit support annex** (CSA) incorporated into an ISDA Master Agreement is to allow the parties to the agreement to mitigate credit risk through the posting of collateral. Because collateral can vary greatly in terms of amount, liquidity, and risk levels (as well as many other elements), a CSA is created to govern issues such as

collateral eligibility, interest rate payments, timing and mechanics associated with transfers, posted collateral calculations, haircuts to collateral securities (if applicable), substitutions of collateral, timing and methods for valuation, reuse of collateral, handling disputes, and collateral changes that may be triggered by various events. In order to work as intended, CSAs must define all collateralization parameters and account for any scenarios that may impact both the counterparties and the collateral they are posting.

Parameters established with CSAs (and collateralized agreements in general) include the following:

- **Threshold**: Collateral will be posted when the level of MtM exposure exceeds this threshold level.
- **Initial margin** (also known as **independent amount** in bilateral markets): The amount of extra collateral that is required independent of the level of exposure.
- **Minimum transfer amount**: The minimum amount of collateral that can be called at a given time.
- **Rounding**: Collateral calls or collateral returns may be rounded to specific sizes to avoid working with inconvenient quantities.
- **Haircut**: This reduces the value of collateral to account for the possibility that its price may fall between the previous collateral call and a counterparty default.
- **Credit quality**: As counterparty credit quality declines, the importance of collateral increases.
- **Credit support amount**: The amount of collateral that may be called (by either counterparty) at a certain point in time.

Professor's Note: The terms of a collateral agreement as well as descriptions of threshold, initial margin, minimum transfer amount, rounding, haircuts, and credit quality will be addressed in LO 26.6 when we explain the features of a collateralization agreement.

Valuation Agents

LO 26.3: Describe the role of a valuation agent.

The valuation agent is responsible for calling for the delivery of collateral and handles all calculations. The valuation agent's role is to calculate (1) credit exposure, (2) market values, (3) credit support amounts, and (4) the delivery or return of collateral. Larger entities often insist on being valuation agents when dealing with smaller counterparties. When the size difference between counterparties is small, both counterparties may be valuation agents. In this case, each entity would call for collateral when they have positive exposure; however, this could lead to disputes and delays in processing collateral movements. One remedy is to use a third-party valuation agent that would handle the collateral process, processing collateral substitutions, resolving disputes, and producing daily valuation reports.

Collateral Agreements and Types of Collateral

LO 26.4: Describe the mechanics of collateral and the types of collateral that are typically used.

The process of collateralization is typically done through legal documents under which parties negotiate collateral supporting documents that state the terms and conditions of the process. Collateral agreements should quantify parameters and specify the currency, type of agreement (one-way or two-way), what collateral is eligible, timing regarding delivery and margin call frequency, and interest rates for cash collateral. Trades between counterparties are then marked-to-market (MtM) on an ongoing basis (typically daily), and valuations including netting are determined. The party with the negative MtM exposure then delivers collateral to the other side of the transaction, and the collateral position is updated.

There are many types of collateral used, depending on the riskiness of the credit exposures. Collateral can include cash, government and government agency securities, mortgage-backed securities, corporate bonds and commercial paper, letters of credit, and equity. The most common type of collateral is cash; however, during extreme market events, the supply of cash collateral can be limited. Other collateral types, including agency securities, are often preferred for liquidity; however, recent market events have led to questioning the true riskiness of these securities. In addition, noncash collateral may give rise to problems with rehypothecation (defined later) and create price uncertainty.

Collateral Coverage, Disputes, and Resolutions

LO 26.5: Explain the process for the reconciliation of collateral disputes.

To mitigate risk, it is generally preferred to include the maximum number of trades in collateral agreements. However, if even a single trade cannot be properly valued, it can complicate collateral calls and may lead to collateral disputes. If trades include potentially problematic assets, it may be optimal to only focus on a subset of trades that make up the majority of credit exposure and leave out asset classes that are hard to value either due to complexity (e.g., exotic options) or illiquidity (e.g., credit derivatives). Global considerations are also important, especially as counterparties trade with each other over many time zones and geographical locations. It may be optimal to handle trades separately with regions that are problematic and make up only a small portion of trades. Finally, if an entity expects one of its counterparties to have difficulty valuing certain trades or assets, it may be preferred to leave those trades uncollateralized rather than face potential and frequent disputes. Given that collateral agreements typically require that undisputed amounts be transferred immediately, it is generally advantageous to collateralize the majority of products.

If disputes do arise, they can relate to the trade population, trade valuation, netting rules, market data and market closing time, and valuing collateral that was previously posted. If the disputed amount or valuation difference is small, counterparties may simply split the difference. If the disputes involve larger differences, the exposure will remain uncollateralized until the dispute is resolved. Disputes include the following steps: (1) the disputing party notifies the counterparty of its intent to dispute the exposure by the end

of the day following the collateral call; (2) all undisputed amounts are transferred, and the reason for the dispute is identified; and (3) for unresolved disputes, the parties will request quotes from several market makers (usually four) for the MtM value.

Reconciling trades minimizes the chance of disputes. Parties may also find it beneficial to perform dummy (practice) reconciliations prior to trading and periodic reconciliations during trading (weekly or monthly) to preempt future disputes.

Collateral Agreement Features

LO 26.6: Explain the features of a collateralization agreement.

Collateral agreements are typically negotiated prior to any trading, and they are often updated prior to an increase in trading. Parameters must be clearly defined, and parties must balance the work involved in calling and returning collateral with the benefits of risk mitigation.

Terms of a collateral agreement may be linked to the credit quality of counterparties in order to minimize operational workload while maintaining the ability to tighten collateral terms when a party's credit quality declines. Counterparties most commonly link a tightening of collateral terms to changes in credit rating (e.g., to a downgrade in rating to below investment grade). While this approach is easy to set up, it can lead to issues by requiring the downgraded counterparty to post collateral exactly at a time when it is experiencing credit issues. This can lead to a "death spiral" of the affected counterparty, as the counterparty faces multiple collateral calls. As a result, it may be preferable to link collateral terms not to the credit rating of entities, but to credit spreads, the market value of equity, or net asset values.

Margin calls should be done at least daily. Products like repos and swaps that are cleared via central counterparties most often have intraday margining. While longer margin frequencies likely reduce operational workloads, daily margining has, more or less, become the market norm.

Threshold in margining refers to the level of exposure below which collateral will not be called. As a result, threshold represents the level of uncollateralized exposure, and only the incremental amount above the threshold would be collateralized. Thresholds generally aim to reduce the operational burden of calling collateral too frequently. A threshold of zero means any exposure is collateralized, while a threshold of infinity means all exposure is uncollateralized. Thresholds are most often linked to credit ratings in a tiered manner, with lower credit ratings corresponding to lower or zero threshold amounts.

Initial margin is the collateral amount that is posted upfront and is "independent" of any subsequent collateralization. It is often used to mitigate the widening of credit spreads or declines in equity values. Initial margin is typically required by stronger credit quality counterparties or by the counterparty more likely to have positive exposures and represents a level of **overcollateralization**. Initial margins are also typically linked to the credit rating of counterparties in a tiered manner; however, as opposed to thresholds, the level of intitial margin *increases* with lower ratings. Intiail margins can be thought of as converting counterparty risk into gap risk, ensuring that the less risky counterparty always remains

overcollateralized by this amount without incurring losses, even when the risky counterparty defaults. Initial margins should, therefore, be large enough to minimize the gap from large value movements of trades should the risky counterparty default.

A **minimum transfer amount** represents the smallest amount of collateral that can be transferred. A minimum transfer amount is used to reduce the operational workload of frequent transfers for small amounts of collateral, which must be balanced against the benefits of risk mitigation. It is important to note that the threshold and minimum transfer amount are additive; that is, exposure must exceed the sum of *both* before a collateral call can be made. Minimum transfer amounts are also typically tied to credit ratings, with higher ratings corresponding to higher amounts.

Collateral amounts typically use **rounding** (e.g., to the nearest thousand) to avoid transferring very small amounts during collateral calls or returns.

A **haircut** is essentially a discount to the value of posted collateral. In other words, a haircut of x% means that for every unit of collateral posted, only (1 – x)% of credit will be given. This credit is also referred to as valuation percentage. Cash typically has a haircut of 0% and a valuation of 100%, while riskier securities have higher haircut percentages and lower corresponding valuation percentages.

For example, if a particular sovereign bond has a haircut of 2% and a collateral call of $100,000 is made, only 98% of the collateral's value is credited for collateral purposes. That is, in order to satisfy a $100,000 collateral call, $102,041 ($100,000 / 0.98) of the sovereign bond must be posted (or $100,000 in cash).

It is easy to see that riskier securities have greater haircuts to account for their volatility, which may lead to a decline in their value. In the order of increasing riskiness and higher haircuts, cash typically has no haircuts, followed by high-quality government bonds, triple-A rated corporate bonds, structured notes or products, and, finally, equities and commodities. Key factors to consider when assessing haircuts are time to liquidate collateral, volatility of the collateral's underlying market, and the default risk, maturity, and liquidity of the security. Assessing haircuts will often depend on current market conditions using sophisticated value at risk (VaR) calculations.

Entities usually pay interest, coupons, dividends, and other cash flows to counterparties posting collateral as long as the counterparty is not in default. Interest on cash collateral is paid at an overnight market rate. During times of high volatility and illiquid markets, cash collateral is generally preferred, and entities may pay higher-than-market interest rates as an incentive to the entity posting collateral.

We will now look at substitution, reuse, and rehypothecation of collateral. Counterparties sometimes require that the original posted collateral be returned to them for various reasons, including meeting certain delivery commitments. In this case, they can make a **substitution** request by posting an equivalent value of some other eligible collateral. Substitution requests cannot be refused by the other party if the substituted collateral meets all eligibility criteria. Noncash collateral may also be sold, used in repo transactions, or rehypothecated.

Rehypothecation refers to transferring posted collateral to other counterparties as collateral. While widespread, rehypothecation carries two related risks. Consider a scenario where

party A pledges collateral to party B; party B rehypothecates this collateral to party C. If party C defaults, then party B will not only have a loss from not receiving the collateral from party C, it will also have a liability to party A for not returning its collateral. The practice of rehypothecation was relatively widespread prior to the 2007–08 credit crisis; however, it has been significantly less popular following the crisis. Parties now increasingly prefer cash collateral.

CSA Agreements

LO 26.7: Differentiate between a two-way and one-way CSA agreement and describe how collateral parameters can be linked to credit quality.

There may be instances when CSAs are not used. Institutions may be unable or unwilling to post collateral. This may be because their credit quality is far superior to their counterparty or they cannot commit to the operational and liquidity requirements that arise from committing to a CSA.

A **two-way CSA** is often established when two counterparties are relatively similar, as it will be beneficial to both parties involved. It is important to note that the two sides may not be treated equally, as certain key parameters (like threshold and initial margin) may differ depending on the respective risk levels of each party.

A **one-way CSA** differs from a two-way CSA in that the former only requires that one counterparty post collateral (either immediately or after a specific event, such as a ratings downgrade). As a result, the CSA will be beneficial to the receiver of the collateral and at the same time will present additional risk for the counterparty posting the collateral. These types of CSAs are established when two counterparties are significantly different in size, risk levels, et cetera.

The terms of a collateral agreement are usually linked to the credit quality of the counterparties in a transaction. This is beneficial when a counterparty's credit quality is strong because it minimizes operational workload. However, it is also beneficial when a counterparty's credit quality is weak as it allows the other party to enforce collateralization terms triggered by a quality downgrade. Although credit ratings are the most common quality linked, others include market value of equity, net asset value, and traded credit spread. The benefits of linking to credit ratings must be weighed against the costs associated with the requirement of collateral when a ratings downgrade occurs.

Collateral Agreement Risks

LO 26.8: Explain how market risk, operational risk, and liquidity risk (including funding liquidity risk) can arise through collateralization.

Collateralization may improve asset recovery in the event of a counterparty default, but it should be viewed as a supplement to, not a replacement for, ongoing due diligence review of credit quality and exposure. Use of collateral may be viewed as a double-edged sword. When managed properly, it can mitigate risks, but when managed poorly, it may well give rise to additional risks. Collateral agreements could potentially cause the following risks.

Market Risk

Market risk relates to the degree of market movements that have occurred since the last posting of collateral. It is relatively small compared to the risk of an uncollateralized situation, but market risk is a challenge to hedge and to quantify.

Even though collateral is in place to mitigate counterparty risk, there will always be some residual risk due to parameters such as minimum transfer amounts and thresholds that delay the collateral process. In addition, even when collateral is called, there will be a normal delay in sending/receiving the collateral. This delay is represented as the margin period of risk, which is the effective time between a collateral call and the receipt of the collateral.

Operational Risk

Potential pitfalls in the handling of collateral include missed collateral calls, failed deliveries, computer error, human error, and fraud. Proper controls must be in place to reduce the likelihood of the occurrence of any one of the foregoing items. Examples of proper controls would be the existence of accurate and enforceable legal agreements, robust IT systems capable of automating many steps in the process, timely and accurate valuation of the collateral, current information on initial margins, minimum transfer amounts, rounding, a requirement that collateral types and currencies must be available for each counterparty, and careful observation of the failure to deliver collateral.

Liquidity and Liquidation Risk

Transaction costs may result when having to liquidate collateral to mitigate counterparty risk. These are often in the form of a bid-ask spread or selling costs. Liquidating a security in an amount that is large relative to its typical trading volume may negatively impact its price, leading to a substantial loss. The alternative is to liquidate a position slowly. With this approach, the counterparty is exposed to market volatility during the period of liquidation. Additional considerations regarding liquidity risk include:

- How large is the market capitalization of the issue posted as collateral?
- Is there a link between the value of the collateral and the counterparty's credit quality? This would be an example of wrong-way risk (when credit exposure and default risk both increase at the same time).
- Would the liquidity of the collateral change due to a default by the counterparty?

Funding Liquidity Risk

Funding liquidity risk refers to the ability of an institution to settle its obligations quickly when they become due, which results from the funding needs established in a CSA. For various reasons, collateral agreements are not in place for many OTC derivatives transactions. When a counterparty does not have the operational capacity or liquidity to handle frequent collateral calls (required under a CSA), the counterparty will be vulnerable to funding implications. This risk is relatively small when markets are liquid and funding costs are low. However, when markets are illiquid, the risks become higher because funding costs can increase considerably.

Default Risk

The default of a security posted as collateral will lower its value (when the loss in value is unlikely to be covered by a haircut). Cash or high-quality fixed-income securities are usually the preferred type of collateral. Should the collateral's credit rating fall below what the collateral agreement specifies, then it would need to be replaced. Poor collateral may fail to mitigate counterparty risk.

Foreign Exchange Risk

Foreign exchange risk occurs when counterparties have different currencies. Collateral carrying foreign exchange risk can be hedged in spot and forward markets. The process must be done carefully due to the dynamic and changing value of the collateral.

Key Concepts

LO 26.1

Collateral is an asset supporting a risk in a legally enforceable way. Collateral management is often bilateral, where either side to a transaction is required to post or return collateral to the side with the positive exposure.

LO 26.2

A credit support annex (CSA) allows parties to mitigate credit risk through the posting of collateral. The CSA provides governance on many issues related to the collateral itself, including what may be used, when and how it should be valued and transferred, and any changes that must be made upon the occurrence of certain events. A CSA will also define key parameters such as the threshold, minimum transfer amount, and initial margin.

LO 26.3

The role of the valuation agent is to call for the delivery of collateral and handle any collateral-related calculations, including credit exposure, market values, credit support amounts, and the delivery/return of collateral. One or both parties to an agreement may be the valuation agent, or alternatively, a third party agent may be used.

LO 26.4

Collateralization involves the party with the negative exposure posting collateral in the form of cash or securities to the party with the positive exposure. Collateral can include cash, government and government agency securities, mortgage-backed securities, corporate bonds and commercial paper, letters of credit, and equity. The most common type of collateral is cash.

LO 26.5

Collateral disputes may arise due to the valuation and population of trades, market data and market closing time, netting rules, and valuing collateral previously posted. Managing disputes include the following steps: (1) the disputing party notifies the counterparty of its intent to dispute the exposure by the end of the day following the collateral call; (2) all undisputed amounts are transferred and the reason for the dispute is identified; and (3) for unresolved disputes, the parties will request quotes from several market makers (usually four) for the MtM value. Reconciling trades on a regular basis can minimize potential disputes.

LO 26.6

Threshold is the level of exposure below which collateral will not be called and represents the level of uncollateralized exposure.

Initial margin is the collateral amount that is posted upfront and is independent of any subsequent collateralization. It represents a level of overcollateralization and can be thought of as converting counterparty risk into gap risk to always maintain an overcollateralized position by the stronger credit quality party.

A minimum transfer amount represents the smallest amount of collateral that can be transferred and is used to reduce operational workload. The threshold and minimum transfer amounts are additive.

A haircut is a discount to the value of posted collateral, with cash having the lowest discount (highest credit given). The riskier the security, the higher the haircut and the lower the credit given.

Substitution refers to posting an equivalent value of other eligible collateral. Rehypothecation refers to transferring posted collateral to other counterparties as collateral.

LO 26.7

A one-way CSA requires one counterparty to post collateral, while a two-way CSA requires both sides to post collateral. For a two-way CSA, certain key parameters may differ if the parties' have different risk levels.

Collateral agreements are often linked to the credit quality of the counterparties in a transaction, in particular credit ratings. While this linking can be beneficial to one party if the other party's credit rating declines, there are costs associated with requiring collateral when a ratings downgrade occurs.

LO 26.8

Key risks involved as a result of entering into a collateral agreement include the following: market risk (unfavorable market movements since the last collateral posting), operational risk (operational issues in the handling of collateral transactions), liquidity and liquidation risk (the ability to liquidate collateral without an unexpected or substantial loss in value), and funding liquidity risk (the ability to meet funding obligations as they come due).

Concept Checkers

1. Which of the following features is least likely a benefit of collateralization?
   A. Reduces capital requirements.
   B. Allows for more competitive pricing of counterparty risk.
   C. Reduces market, operational, and liquidity risk.
   D. Reduces credit exposure.

2. Collateral agreements could potentially create multiple risks, including liquidity and liquidation risks. Which of the following is most accurate regarding liquidity and liquidation risk?
   A. Liquidation risk occurs when the amount of a security sold is large relative to its outstanding volume, which may affect the price of that security.
   B. Liquidity risk must be hedged in spot and forward markets.
   C. Liquidation risk embodies a transaction cost when collateral is liquidated in accordance with initial margin.
   D. Liquidity risk occurs when there are potential pitfalls in the handling of collateral, including human error.

3. When dealing with a hedge fund, a bank would most likely negotiate a(n):
   A. one-way agreement in the bank's favor given the bank's stronger credit rating.
   B. one-way agreement in the bank's favor agreeing to post collateral to the hedge fund.
   C. two-way agreement given the relatively small difference in credit quality between the two entities.
   D. two-way agreement where both parties agree to post collateral.

4. Assume a sovereign bond has a haircut of 5% and is used for a collateral call of $100,000. What amount is credited if a $100,000 bond is submitted, and what amount of bond is needed for $100,000 to be credited, respectively?
   A. $100,000; $106,263.
   B. $95,000; $100,000.
   C. $95,000; $105,263.
   D. $105,263; $95,000.

5. Which of the following statements is least accurate regarding a credit support annex (CSA) and/or an ISDA Master Agreement?
   A. ISDA Master Agreements help standardize collateral management.
   B. CSAs must define all collateralization parameters in order to work as intended.
   C. Compared to the ISDA Master Agreement, CSAs were first to establish collateral standards.
   D. CSAs are incorporated into an ISDA Master Agreement.

Concept Checker Answers

1. **C** Collateralizing trades reduces credit exposure (credit risk) and capital requirements, and allows for more competitive pricing of counterparty risk. However, collateralization also creates other risks including market risk (negative equity leaving exposures partially or fully uncollateralized), operational risk (legal obstacles to take possession of collateral), and liquidity risk (difficulty in selling collateral at a fair market value).

2. **A** Liquidating a security in an amount that is large relative to its typical trading volume may negatively impact its price, leading to a substantial loss.

3. **A** The bank would most likely negotiate a one-way agreement in its own favor given the higher credit quality of the bank. This type of negotiation is typical when there are large differences in credit quality between two entities.

4. **C** A haircut is essentially a discount to the value of posted collateral. In other words, a haircut of x% means that for every unit of collateral posted, only (1 – x)% of credit will be given. This credit is also referred to as valuation percentage. If a particular sovereign bond has a haircut of 5% and a collateral call of $100,000 is made, only 95% of the collateral's value is credited for collateral purposes. That is, in order to satisfy a $100,000 collateral call, $105,263 ($100,000 / 0.95) of the sovereign bond must be posted.

5. **C** The purpose of a credit support annex (CSA) incorporated into an ISDA Master Agreement is to allow the parties to the agreement to mitigate credit risk through the posting of collateral. A CSA is created to govern issues such as collateral eligibility, interest rate payments, timing and mechanics associated with transfers, posted collateral calculations, haircuts to collateral securities (if applicable), substitutions of collateral, timing and methods for valuation, reuse of collateral, handling disputes, and collateral changes that may be triggered by various events. In order to work as they are intended to work, CSAs must define all collateralization parameters and account for any scenarios that may impact both the counterparties and the collateral they are posting.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Credit Exposure and Funding

Topic 27

Exam Focus

In this topic, we describe credit exposures for various security positions. For the exam, understand credit exposure metrics and their application. Be prepared to identify potential future exposure (PFE) for the various asset classes discussed. Understand how credit exposure and VaR methods compare, and be able to explain credit exposure factors. Know how payment frequencies and exercise dates impact exposure profiles. Also, be familiar with netting tables and be able to calculate the netting factor. Understand the impact of collateral attributes on credit exposure reduction and know the steps in the remargin period. Finally, be able to explain the difference between risk-neutral and real-world parameters in arbitrage models and risk management applications.

Credit Exposure Metrics

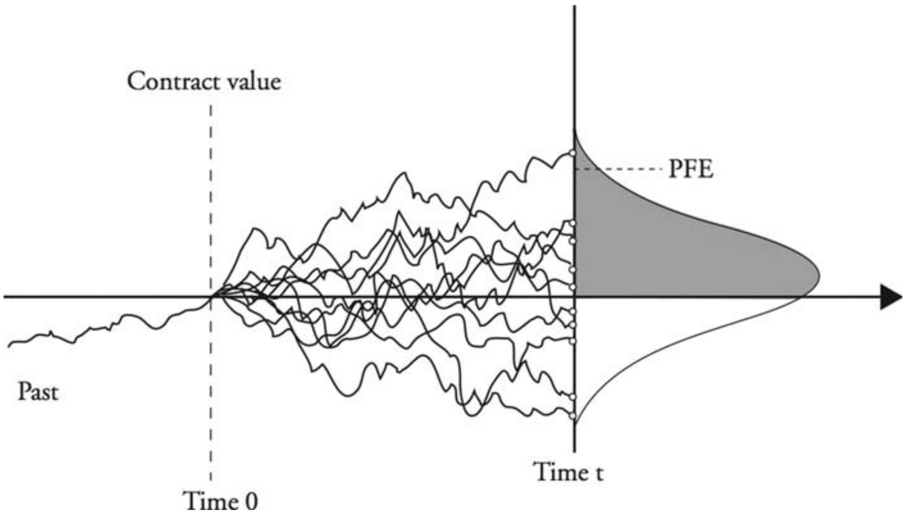
LO 27.1: Describe and calculate the following metrics for credit exposure: expected mark-to-market, expected exposure, potential future exposure, expected positive exposure and negative exposure, effective exposure, and maximum exposure.

Expected mark to market (MtM) is the expected value of a transaction at a given point in the future. Long measurement periods as well as the specifics of cash flows may cause large differences between current MtM and expected MtM.

Expected exposure (EE) is the amount that is expected to be lost if there is positive MtM and the counterparty defaults. Expected exposure is larger than expected MtM because the latter considers both positive and negative MtM values.

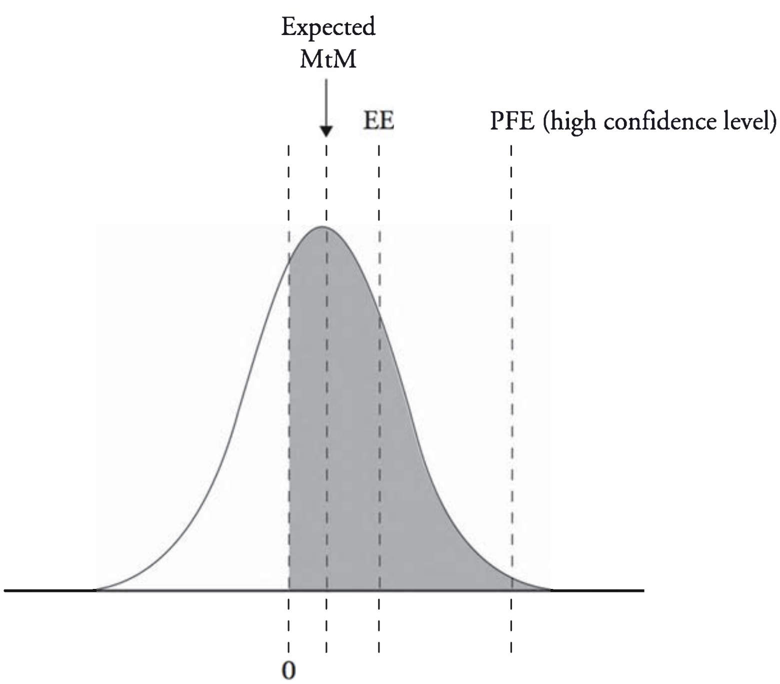
Potential future exposure (PFE) is an estimate of MtM value at a specific point in the future. It is usually based on a high confidence level, taking into account the worst-case scenario. The current MtM may follow a number of different possible paths into the future, so a probability distribution of PFE can be derived, similar to the one shown in Figure 1. Positive MtM (the shaded area in Figure 1) is the part of the exposure that is at risk. Any points in this shaded area can represent PFE.

Figure 1: Potential Future Exposure



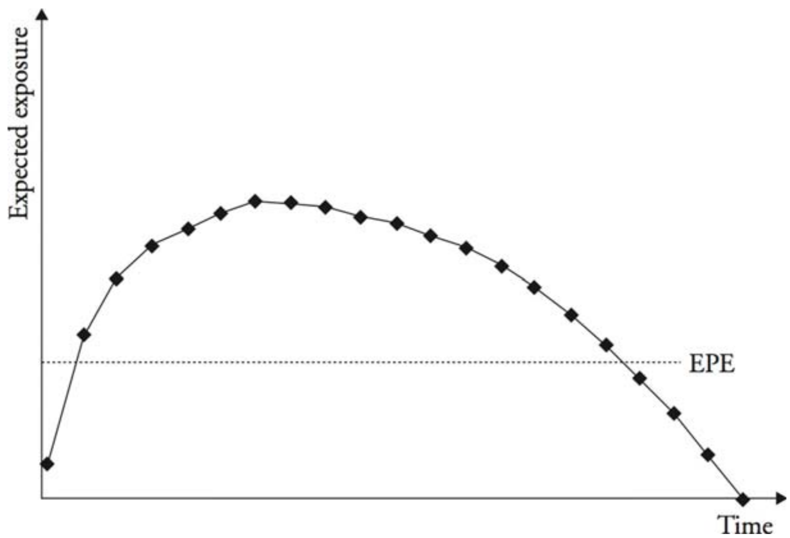
In other words, PFE is the worst exposure that could occur at a given time in the future at a given confidence level. Potential future exposure represents a "gain" amount because it is the amount at risk if the counterparty defaults. **Maximum PFE** is the highest PFE value over a stated time frame.

Figure 2: Credit Exposures



Expected positive exposure (EPE) is the average EE through time. Expected positive exposure is a useful single amount to quantify exposure.

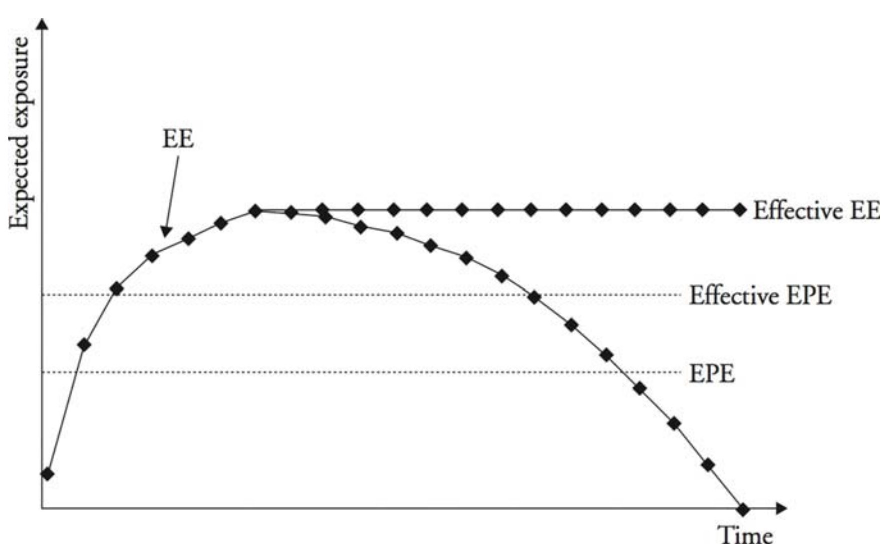
Figure 3: Expected Positive Exposure



Negative exposure, which is the exposure from the counterparty's point of view, is represented by negative future values. The expected negative exposure (ENE) and the negative expected exposure (NEE) are the exact opposite of EPE and EE.

The **effective EE** and **effective EPE** measures are meant to properly capture rollover risk for short-term transactions (under one year). Effective EE is equal to nondecreasing EE. Effective EPE is the average of the effective EE.

Figure 4: Effective EE and Effective EPE



Comparing Credit Exposure to VaR Methods

LO 27.2: Compare the characterization of credit exposure to VaR methods and describe additional considerations used in the determination of credit exposure.

Value at risk (VaR) is a measure used to estimate the risk of loss on a portfolio of financial/investment assets (e.g., stocks, bonds, derivatives, etc.). For example, if an asset portfolio has a one-day 10% VaR of $100,000, there is a 10% probability that the market value of the portfolio will fall by more than $100,000 over a period of one day. The characterization of credit exposure is similar to the characterization of VaR, although additional considerations are relevant to credit exposure, described as follows:

- *Application*: Credit exposure is defined for both pricing and risk management, whereas VaR is just for risk management. As a result, quantifying credit exposure is more difficult and may result in different calculations for both pricing and risk management purposes.
- *Time horizon*: VaR models are based on a relatively short time horizon, whereas credit exposure must be defined over many time horizons. The trend (i.e., drift) of market variables, their underlying volatility, and their levels of co-dependence become relevant for credit exposure, whereas for VaR, these elements are irrelevant due to the short time horizon. Also, while VaR tends to ignore future contractual payments and changes such as exercise decisions, cash flows, and cancellations, credit exposure must take these elements into account because they tend to create path dependency (i.e., credit exposure in the future depends on an event occurring in the past).
- *Risk mitigants*: Netting and collateral are examples of risk mitigants, designed to reduce the level of credit exposure. In order to estimate future levels of credit exposure, these mitigants need to be taken into account. Netting requires that the proper rules be applied, which may add a level of complexity. Future collateral adds a significant element of subjectivity, as the type of collateral and time to receive collateral must all be modeled even though they may be unknown.

Credit Exposure Factors

LO 27.3: Identify factors that affect the calculation of the credit exposure profile and summarize the impact of collateral on exposure.

The credit exposure profile is impacted by several factors, including:

- *Future uncertainty*: In situations where there is a single payout at the end of the life of a contract, uncertainty regarding the value of the final exchange increases over time. Foreign exchange forwards and FRAs often have single payouts at the end of their contract lives.
- *Periodic cash flows*: Unlike the situation where there is a single payout, when cash flows occur regularly, the negative impact of the future uncertainty factor is reduced. However, additional risk exists when periodic cash flows are not equal in each period and are based on variables that may change as is often the case in an interest rate swap with variable interest rates.

- *Combination of profiles*: This exists when the credit exposure of a product results from the combination of multiple underlying risk factors. A cross-currency swap (which combines a foreign exchange forward trade with an interest rate swap) is a good example of this factor.
- *Optionality*: Exercise decisions (e.g., a swap-settled interest rate swaption) will have an impact on credit exposure.

Collateral will also have a significant impact on credit exposure, as it typically reduces the level of credit exposure. However, determining the true level of risk reduction must take into account key parameters (e.g., minimum transfer amounts, thresholds, etc.); the margin period of risk; and other risks associated with collateral such as liquidity, operational risk, and legal risk.

In addition, the reality is that risk is not removed entirely even with collateral due to factors such as delays in receiving collateral, variations in collateral value (i.e., when the collateral is something other than cash), the granularity effect (i.e., key parameters prevent asking for all of the collateral actually required), and the path dependency of collateral (i.e., the amount called for depends on the amount collected in the past).

Security Exposure Profiles

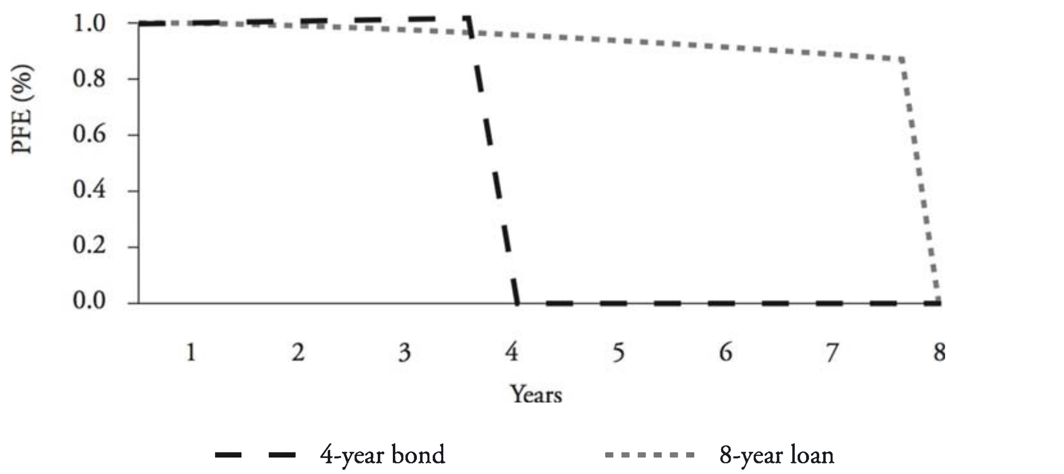
LO 27.4: Identify typical credit exposure profiles for various derivative contracts and combination profiles.

Potential future exposure (PFE) is defined as the maximum expected credit risk exposure for a specified period of time at a prespecified level of confidence. PFE is a measure of counterparty and credit risk exposures. Thus, the maximum credit risk exposure indicated by a PFE analysis is the upper bound on a confidence interval for future credit risk exposure. The ability to quantify counterparty credit exposure is impacted by time to maturity. There is more uncertainty related to market variables further into the future.

Examples of PFE are used to illustrate the credit exposure profile of various security types that result from different sources (e.g., maturity, option exercise, payment frequencies, default risk, and roll-off risk). In this section, a 99% confidence level is used to create the PFEs.

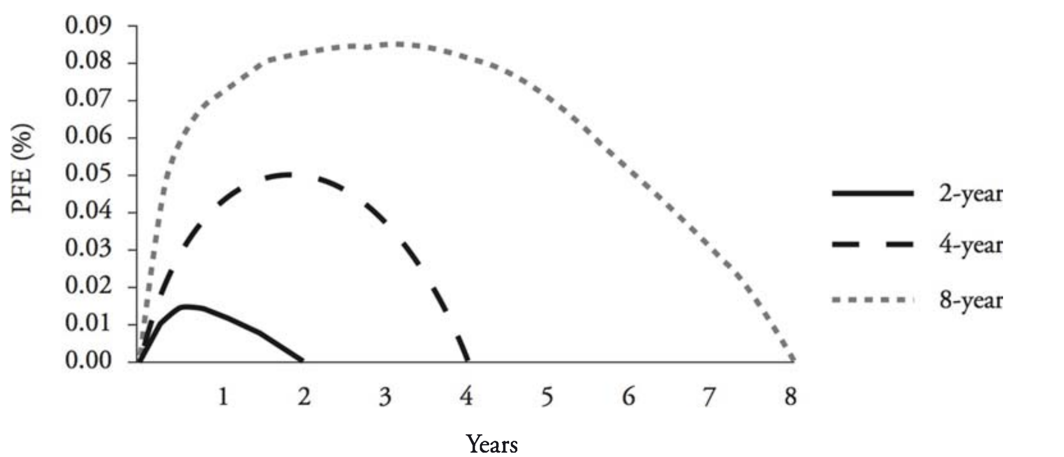
The PFE of bonds, loans, and repos are approximately equal to the notional value. The additional exposure of a four-year bond, as shown in Figure 5, is the result of interest rate risk. Bonds typically pay a fixed interest rate. If interest rates decline, then the exposure may increase. Figure 5 also illustrates the exposure for an eight-year loan. Loans typically have variable interest rates, and the exposure over time may decrease as a result of prepayments.

Figure 5: Loan and Bond PFE



Exposure profiles of swaps are typically characterized by a peak shape, as illustrated in Figure 6. This peaked shape results from the balancing of future uncertainties over payments and the roll-off risk of swap payments over time.

Figure 6: Interest Rate Swap PFE



The high volatility of FX rates, long maturities, and large final payments of notional value result in monotonically increasing exposures for foreign exchange products. Figure 7 illustrates that there is some exposure associated with interest rate risk (IR); however, the majority of the exposure results from the uncertainty regarding the final notional value payment associated with FX rate risk.

Figure 7: Three-Year Cross-Currency Swap PFE (Exposure Impact of Interest and FX Rates)

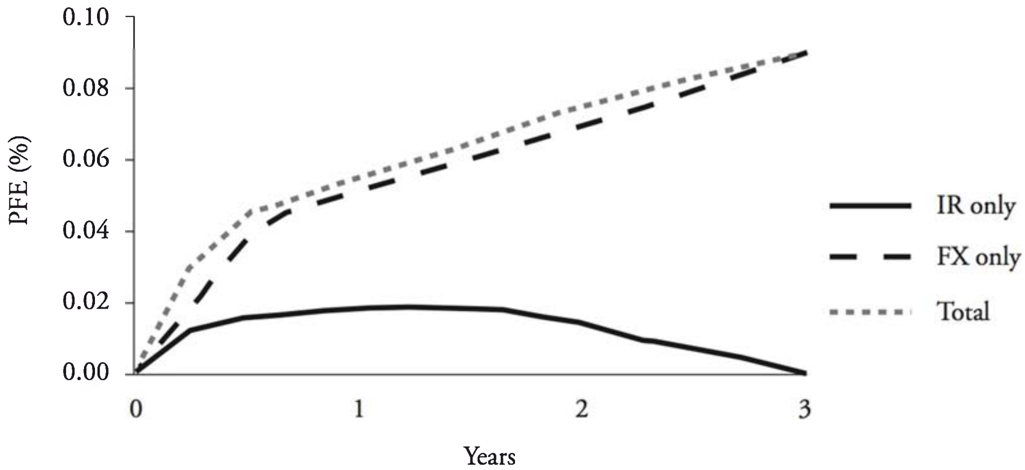
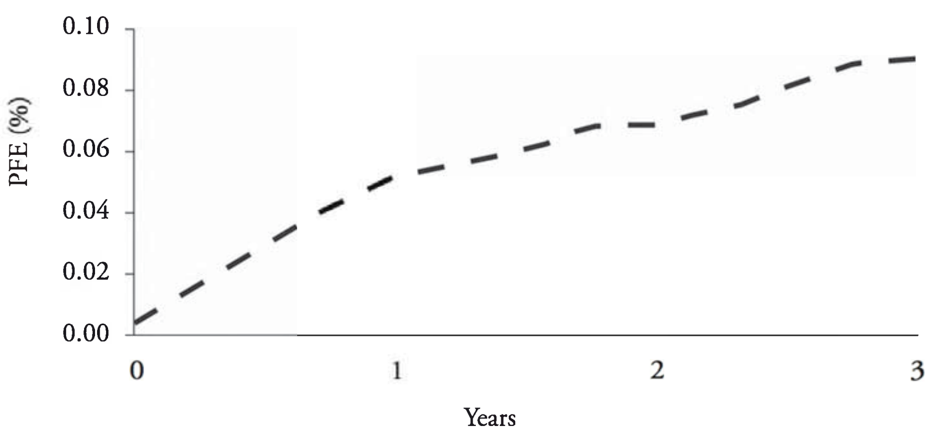


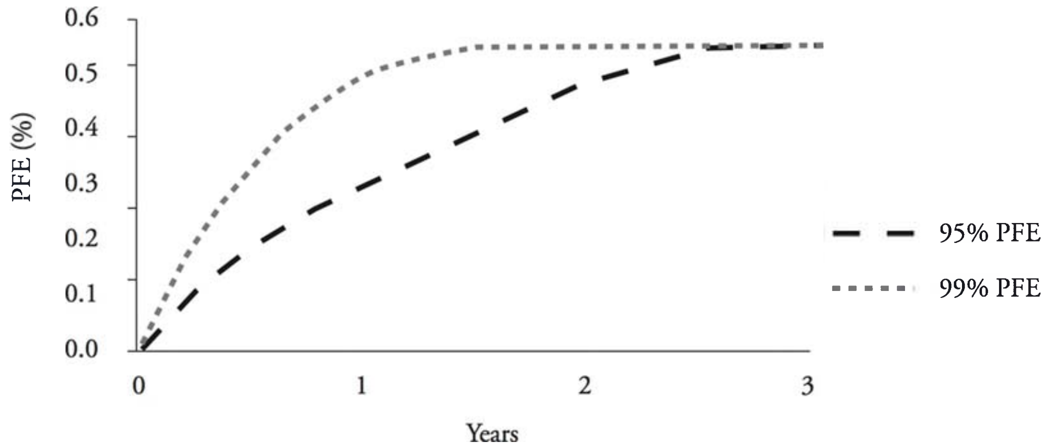
Figure 8 provides an exposure profile for a long option position (with up-front premium) and illustrates the increase over time of the exposure until the option is exercised. The exact shape of the graph can change when the option is near, in, or out of the money. However, the increase over time is similar for all options due to the fact that the option can be deep in the money.

Figure 8: Option PFE



The effect of **wrong-way risk** leads to considerable counterparty risk for credit derivatives. Figure 9 illustrates the exposures for a long-protection credit default swap (CDS) at the 95% and 99% confidence levels. The increase in exposures in early years is the result of the CDS premium (or credit spread) widening. The maximum exposure for the CDS occurs at a credit event where the notional value is paid less the recovery value. The 55% final exposure in this example is the result of a 45% recovery rate.

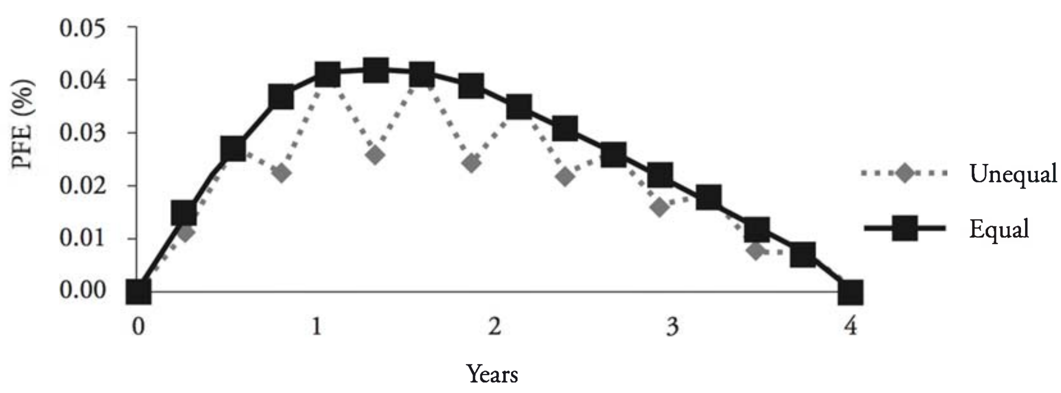
Figure 9: Credit Derivative PFE



LO 27.5: Explain how payment frequencies and exercise dates affect the exposure profile of various securities.

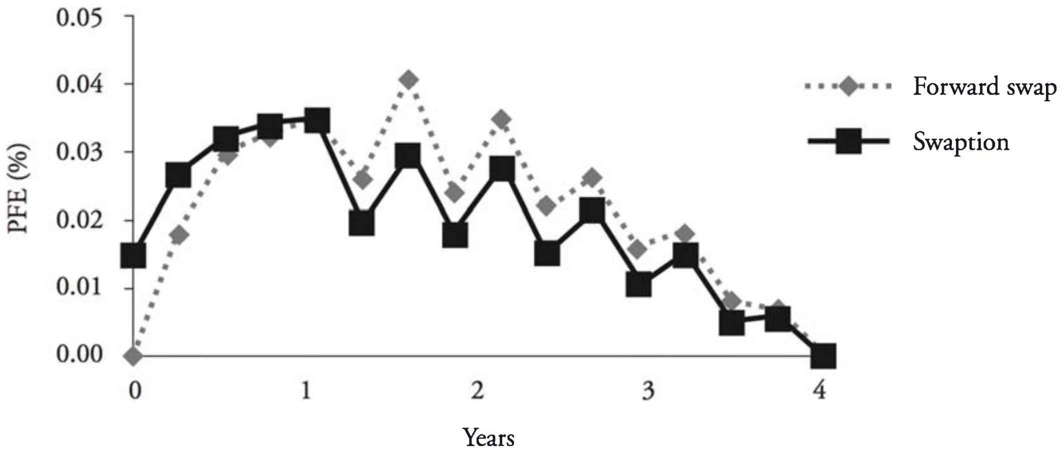
To illustrate the impact of payment frequencies, we can compare interest rate swap PFEs, assuming semiannual fixed payments are made and floating quarterly payments are received. Figure 10 illustrates that with unequal payments there is reduced exposure when payments are received more frequently than payments are made. Conversely, if a PFE were created for an interest rate swap where interest payments made were more frequent than interest payments received, it would have the reverse effect. In that case, the unequal payment PFE would show greater exposure than the equal payment PFE.

Figure 10: PFE for Swap With Equal and Unequal Interest Payments



Exercise dates result in more complex exposure profiles as illustrated in Figure 11, which shows an exposure profile for an interest rate swaption and forward swap with an exercise date of one year. The swaption in this example is swap-settled (as opposed to cash-settled) on the expiration date. The payment frequencies also differ for the swaps in this example. When compared to a forward swap, notice that the exposure is greater for the swaption prior to the one-year exercise date. This relationship reverses after the exercise point and the exposure for the forward swap is greater than the exposure for the swaption. This greater exposure is due to the fact that in some scenarios the forward swap has a positive value and the swaption is not exercised.

Figure 11: PFE for Interest Rate Swaption and Forward Swap



Modeling Netting Agreements

LO 27.6: Explain the impact of netting on exposure, the benefit of correlation, and calculate the netting factor.

Netting agreements allow two parties to net a set of positions should one of the parties default. This type of risk is effectively modeled in Monte Carlo simulations. The benefits of netting are realized when MtM values have opposite signs for two trades. Thus, the netting calculation is done at the individual level prior to calculating the total expected exposure (EE). A single time horizon netting factor is defined by EE, and a weighted average EE over time defines the expected positive exposure (EPE).

It is also important to consider the relationship between netting and correlation. Positive correlations have lower netting benefits than negative correlations, with perfect positive correlation providing the least netting benefit. High positive correlations likely result in trades that are of the same sign, resulting in a small or zero netting benefit.

Figure 12: Netting With Positive Correlations

	MtM		*Total Exposure*		
	Trade 1	*Trade 2*	*No netting*	*Netting*	*Netting benefit*
Scenario 1	15	5	20	20	0
Scenario 2	5	–5	5	0	5
Scenario 3	–5	–15	0	0	0
EE			8.3	6.7	1.7

Professor's Note: EE, or expected exposure, is the average of the netting figures assuming equal weight.

We can, therefore, easily see that negative correlations provide stronger netting benefits, with perfect negative correlation leading to the greatest netting benefit. In this case, trades are perfectly offsetting, and the netting benefit is 100% because there is zero overall risk.

Figure 13: Netting With Negative Correlations

	MtM		*Total Exposure*		
	Trade 1	*Trade 2*	*No netting*	*Netting*	*Netting benefit*
Scenario 1	15	–5	15	10	5
Scenario 2	5	5	10	10	0
Scenario 3	–5	15	15	10	5
EE			13.3	10.0	3.3

Overall, we can derive the following netting formula for the **netting factor** for any set of jointly distributed random variables across different asset classes:

$$\text{netting factor} = \frac{\sqrt{n + n(n-1)\bar{\rho}}}{n}$$

where:
n = number of exposures
$\bar{\rho}$ = average correlation

The netting factor will, therefore, be 100% when there is no netting benefit (correlation is 1) and 0% if the netting benefit is maximized. We also see that the netting benefit improves (i.e., netting factor declines) with a larger number of exposures and a lower correlation. If correlation is zero, the formula simplifies to $1 / \sqrt{n}$, implying that the netting factor for two independent exposures will be reduced to 71%, and for four exposures the netting factor declines to 50%.

Professor's Note: There is a restriction on the correlation level in the netting factor equation. The maximum negative correlation must be bounded by [–1 / (n – 1)] in order to prevent the expression under the square root from becoming negative.

Finally, it is important to note that the netting benefit also depends on the initial MtM of transactions. For example, a trade with strong overall negative MtM under all scenarios will have a strong netting benefit by offsetting some or all of the positive MtM of other trades. Similarly, a trade with strong overall positive exposure under all scenarios will reduce the netting benefit by offsetting some or all of the negative MtM of other trades.

Impact of Collateral on Credit Exposure

LO 27.7: Explain the impact of collateralization on exposure, and assess the risk associated with the remargining period, threshold, and minimum transfer amount.

When Party A has a positive exposure (e.g., receives cash flows in a swap transaction from Party B), Party A is said to have credit exposure because Party B could default. When

exposure (i.e., mark-to-market value) is negative, Party B must post collateral to Party A to minimize the credit risk exposure.

When calculating an exposure profile, a risk manager should understand the factors that affect the collateral's ability to reduce risk. Specifically, factors that affect the calculation of exposure include thresholds, minimum transfer amounts, rounding, initial margin, and the remargin period. These factors will be discussed later in this section.

The **remargin period**, also known as the margin call frequency, is the period from which a collateral call takes place to when collateral is actually delivered. It is a period of extreme exposure to the counterparty seeking collateral. A prudent risk analyst will assume default of the counterparty that must post collateral during the remargin period. Steps that enter into the calculation of the number of days in the remargin period are as follows:

Step 1: *Valuation/margin call*: How long it takes to calculate current exposure to the counterparty and the market value of the collateral. These calculations help to determine if a valid call may be made.

Step 2: *Receiving collateral*: The period between when the counterparty receives the request and when it releases the collateral.

Step 3: *Settlement*: The time it takes to sell the collateral for cash. The type of security being settled determines the time necessary. Cash may be posted on an intraday basis, whereas government and corporate bonds may need one- and three-day settlement periods, respectively.

Step 4: *Grace period*: The amount of time afforded to the counterparty obligated to deliver the collateral in the event that the collateral is not received by the requesting counterparty after the call. This may be a short window of time before the delivering counterparty would be considered in default for a failure-to-pay credit event.

Step 5: *Liquidation/close-out and re-hedge*: The time needed to liquidate the collateral, close out, and re-hedge positions.

An example of a remargin period time line is found in Figure 14, along with the minimum period lengths that must be assumed according to Basel II. Over-the-counter (OTC) derivatives and repurchase agreements (repos) are separated as they are governed by different documentation. The length of a remargin period is a function of the collateral agreement, the counterparty in question, legal considerations, and the management structure of the institution in question. Also, the counterparty requesting the collateral could show leniency toward certain counterparties in the interest of maintaining harmonious business relationships.

Figure 14: Remargin Period Time Line

	OTC Derivatives	*Repos*
Valuation/margin call	2 days	–
Receiving collateral	1 day	1 day
Settlement	2 days	1 day
Grace period	3 days	–
Liquidation/close-out and re-hedge	2 days	1 day
Total	10 days	3 days
Basel II minimum period	10 days	5 days

Measuring Exposure During the Remargin Period

Both expected exposure and potential future exposure measure the volatility of exposure over a given period of time. **Expected exposure** (EE) is the expected value of an exposure at a given point in time. During the remargin period, it is calculated as:

$$EE = \frac{1}{\sqrt{2\pi}} \times \sigma_E \times \sqrt{T_M} \approx 0.4 \times \sigma_E \times \sqrt{T_M}$$

where:
σ_E = volatility of collateralized exposure
$\sqrt{T_M}$ = the remargin frequency (in years)

Potential future exposure (PFE) is what the value of the marked-to-market exposure might be at some future point in time. During the remargin period, it is calculated as:

$$PFE = k \times \sigma_E \times \sqrt{T_M}$$

where:
k = a constant that is a function of the confidence level (e.g., k = 2.33 for a 99% confidence level)

Example: Computing PFE

Calculate the worst-case change in the value of an exposure with 7% annual volatility perfectly collateralized by cash over a 10-day remargin period. Assume 250 trading days in the year and a 99% PFE confidence level.

Answer:

$$PFE = -2.33 \times 7\% \times \sqrt{10/250} = -3.3\%$$

Potential disadvantages of PFE calculations include:

- It assumes a strongly collateralized position. PFE fails to work under a large threshold or minimum transfer amount, which produces a partially uncollateralized exposure.
- The analysis fails to account for the uncertainty of collateral volatility.
- Liquidity and liquidation risks are not considered.
- Volatility may differ from expected or implied volatility at the time of the collateral call and may not assume counterparty default.
- Wrong-way risk is not taken into account.

Collateral volatility must be calculated when a decline in the value of noncash collateral has the potential to create undercollateralization. The PFE formula is used for this calculation.

When there is no correlation between the volatility of the underlying exposure and that of the collateral, overall volatility is calculated as follows:

$$\sqrt{\text{variance of noncash collateral} + \text{variance of underlying exposure}}$$

For example, if the volatility of the noncash collateral was 8% and the volatility of the underlying exposure was 5%, the overall volatility would be computed as:

$$\sqrt{8\%^2 + 5\%^2} = 9.4\%$$

This volatility measure would be used in the PFE formula to reflect the additive exposure of the collateral and volatility of the underlying exposure. In this example, collateral lessens exposure but increases the volatility of the position due to the volatility inherent in the collateral itself.

There are also situations where there is a negative or positive correlation, ρ, between the trade and the collateral. For example, assume a 10-year swap is collateralized with a 15-year government bond that is interest rate–sensitive. The volatilities are 4% for the swap and 6% for the bond. The effective volatility of this position is calculated as follows:

$$\text{effective volatility} = \sqrt{4\%^2 + 6\%^2 - 2 \times 4\% \times 6\% \times \rho}$$

The overall risk of the position as a function of correlation is then calculated as:

$$k \times \text{effective volatility} \times \sqrt{T_M}$$

Modeling Collateral

Quantifying how much collateral reduces credit exposure is important. The risks that arise during the process of collateralizing exposure are discussed here.

Collateralization may be deficient due to terms in the collateral agreement, such as threshold, minimum transfer amount, and rounding. These factors may result in less than full collateralization. The following expression represents imperfect collateralization:

$$\text{exposure}_{t-\Delta} > \text{collateral}_{t-\Delta}$$

where:
t = time
Δ = time since collateral was last received (remargin period)

Exposure could increase between margin calls. The increased amount of exposure may not be collateralized. The following expression represents the portion of exposure not collateralized:

$$\text{exposure}_t > \text{exposure}_{t-\Delta}$$

Collateral is path-dependent. This means that the amount of collateral requested depends on how much was requested in the past.

Certain parameters impact the effectiveness of collateral in lessening credit exposure. These parameters are as follows:

1. **Remargin period**: the time between the call for collateral and its receipt.
2. **Threshold**: an exposure level below which collateral is not called. It represents an amount of uncollateralized exposure.
3. **Minimum transfer amount**: the minimum quantity or block in which collateral may be transferred. Quantities below this amount represent uncollateralized exposure as well.
4. **Initial margin**: an amount posted independently of any subsequent collateralization. This is also referred to as the initial margin.
5. **Rounding**: the process by which a collateral call amount will be adjusted (rounded) to a certain increment.

Figuring out how much exposure should be collateralized at a given point in time involves several critical assumptions.

1. *Remargin period*: how long before collateral is received from when it is first requested.
2. *Calculation of collateral called or returned*: this exercise utilizes the aforementioned parameters.
3. *Calculation of collateralized exposure at each point in time*: all amounts called for collateral less the remargin period.

Risk-Neutral vs. Real Probability Measures

A risk-neutral parameter is often assumed in arbitrage pricing models where hedging is used. Conversely, when exposures are calculated for risk management purposes, the parameters are not risk-neutral but are based on real historical data and common sense. Parameters used for drifts and volatilities are market-driven (i.e., risk-neutral) and may not always reflect historical data or expected events.

The length of data to use for parameter estimation has important implications. A shorter data sample window results in poor statistics, while a longer data sample window gives more weight to older, less relevant data. For example, when the volatility of a market suddenly and dramatically increases, a model using a longer data sample window for parameter estimation will only gradually reflect this increase as the data sample window moves forward in time.

An implied volatility will reflect the market uncertainty immediately. However, caution should be used when applying implied volatility parameters in exposure models. This is illustrated in the following example scenario as counterparty risk, interest rate drift, and longer time periods will have important impacts.

Consider the PFE for two cross-currency swaps with the same maturity, where one of the swaps pays a higher interest rate and the other swap receives the higher interest rate payment. The swap paying the higher interest rate has a greater exposure than the reverse swap due to the fact that it has a significantly higher gain on the notional value at the maturity of the swaps. In addition, over the long term, the interest rate drift dominates the implied volatility measure. This causes the PFE for the swap receiving the higher interest rate to remain relatively flat.

Key Concepts

LO 27.1

Important metrics for credit exposure include the following: expected MtM, expected exposure (EE), negative expected exposure (NEE), potential future exposure (PFE), expected positive exposure (EPE), expected negative exposure (ENE), effective EE, effective EPE, and maximum PFE.

LO 27.2

Although value at risk (VaR) and credit exposure are similarly used to estimate the risk of loss, additional considerations related to credit exposure that must be accounted for include how it is applied (exposure is defined for pricing and risk management), the time horizon (exposure has a much longer time horizon than VaR), and risk mitigants (netting and collateral).

LO 27.3

The credit exposure profile is impacted by factors such as future uncertainty, periodic cash flows, profile combinations, and optionality. Collateral will also impact exposure, typically in a favorable way. However, risk reduction may be limited by the existence of key parameters (thresholds, minimum transfer amounts), characteristics of collateral (delays, value variations, granularity, path dependency), and other risks (liquidity, operational, legal) associated with collateral.

LO 27.4

The PFE of bonds, loans, and repos are approximately equal to the notional value or 100%. PFEs of swaps have a peaked shape. PFEs of long option positions or FX products monotonically increase. The maximum PFE for credit default swaps occurs at a credit event where the notional value less the recovery value is paid.

LO 27.5

With unequal payments, there is reduced exposure that results when payments are received more frequently than payments are made. Exercise dates result in more complex exposure profiles.

LO 27.6

Positive correlations between contract mark-to-market values have lower netting benefits than negative correlations, with perfect positive correlation providing the least netting benefit and perfect negative correlation the most benefit.

LO 27.7

The remargin period is the period from which a collateral call takes place to when collateral is actually delivered.

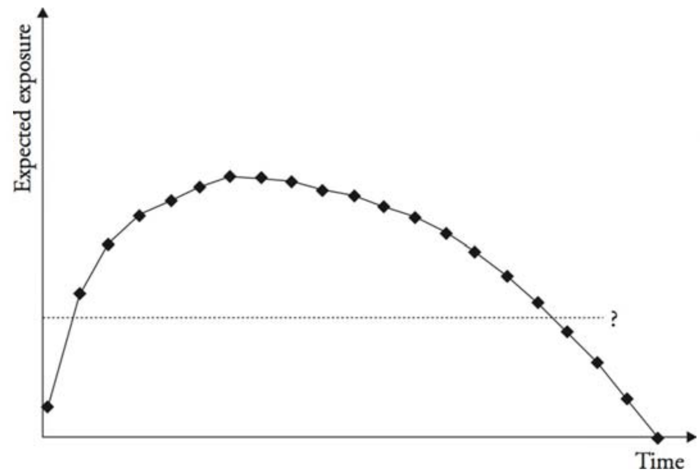
Factors that affect the calculation of the exposure profile when taking collateral into account include:

- Remargin period: creates exposure.
- Minimum transfer amount (≠ threshold amount): creates exposure below the minimum transfer amount.
- Threshold (≠ minimum transfer amount): creates exposure below the threshold.
- Initial margin: may reduce exposure, depending on its size.
- Rounding: may create a small amount of exposure, depending on the direction of the rounding.

Assumptions and parameters in modeling collateral include (1) terms of the collateral agreement, (2) risk of increased exposure between margin calls, and (3) path dependency of collateral.

Concept Checkers

1. Which metric for credit exposure is represented by the "?" in the following graph?



A. Expected positive exposure (EPE).
B. Potential future exposure (PFE).
C. Effective EE.
D. Effective EPE.

2. Miven Corp. has two trades outstanding with one of its counterparties. Which of the following scenarios would result in the greatest netting advantage for Miven?
A. The two trades have strong positive correlation.
B. The two trades have weak positive correlation.
C. The two trades are uncorrelated with each other.
D. The two trades have strong negative correlation.

3. Which of the following security types will most likely result in a peaked shape for the exposure profile represented by potential future exposure (PFE)?
A. Long option position.
B. Foreign exchange product.
C. 10-year loan with a floating rate payment.
D. Swap.

4. Which of the following statements best describes the benefit of netting risk exposures? The benefits of netting are realized when:
A. marked-to-market (MtM) values have high structural correlations for two trades.
B. marked-to-market (MtM) values have opposite signs for two trades.
C. expected exposure (EE) values are minimal.
D. expected future exposure (EFE) values have zero correlation.

5. Time steps that enter into the calculation of the number of days in the remargin period include all of the following except:
   A. valuation/margin call.
   B. posting collateral.
   C. settlement.
   D. close-out and re-hedge.

Concept Checker Answers

1. **A** Expected positive exposure (EPE) is equal to average EE over time. It is a useful single amount to quantify exposure.

2. **D** The greatest netting benefit among the scenarios presented occurs when the two trades have a strong negative correlation. In this case, a large portion of the negative exposures will offset positive exposures.

3. **D** Exposure profiles of swaps are typically characterized by the peaked shape that results from balancing future uncertainties over payments and roll-off risk of swap payments over time.

4. **B** The benefits of netting are realized when MtM values have opposite signs for two trades.

5. **B** The time period from which the request for collateral is received to which it is released refers to the receipt of collateral, but it does not involve its actual posting. All of the remaining items are part of the remargin process.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Counterparty Risk Intermediation

Topic 28

Exam Focus

Traditional, non-cleared markets rely on bilateral trades that leave both counterparties open to default risk and the need to monitor counterparty creditworthiness. This topic focuses on the entities currently providing counterparty risk mitigation. For the exam, understand the structure of the central counterparty (CCP) and the loss waterfall used to reduce systemic risk. Also, be prepared to explain how multilateral netting and collateralization are key enhancements to counterparty risk mitigation. Finally, be able to discuss the effect of CCPs on capital charges.

Counterparty Risk Intermediaries

LO 28.1: Identify counterparty risk intermediaries including central counterparties (CCPs), derivative product companies (DPCs), special purpose vehicles (SPVs), and monoline insurance companies (monolines) and describe their roles.

A **special purpose vehicle** (**SPV**) is an off-balance sheet, bankruptcy-remote entity that can be created by various originators including investment banks and insurance companies. The general idea of an SPV is to create an entity that is separate from its originator but who holds such a high credit quality that default risk is theoretically negligible. Once created, an SPV will borrow money and purchase a series of assets from the originator. The SPV will then repackage the purchased assets into a structured note, like a collateralized debt obligation (CDO), and then sell these assets to investors. The originator will often need to provide a guarantee for the SPV as a counterparty. This may create a double default scenario where both the SPV and the originator are drawn into a counterparty solvency issue.

Professor's Note: Using off-balance sheet entities, like an SPV, is partly what caused companies like AIG, Bear Stearns, and Lehman Brothers to have trouble during the 2007–2009 financial crisis.

The notion of an SPV plays into the argument over which institutions are "too big to fail." These so called **systemically important financial institutions** (**SIFIs**) are common originators of SPVs, and therefore it is assumed by the market that these counterparties will not be permitted to fail. This creates moral hazard whereby some entities are willing to transact with an SPV under the assumption of an implied governmental backstop. Lehman Brothers proved this theory wrong in September 2008.

A special purpose vehicle, also sometimes called a special purpose entity (SPE), theoretically transforms counterparty risk into a type of legal risk. The legal risk is that a bankruptcy court might consolidate the assets of an SPV with their originator in the event of default.

This would treat the SPV assets as if they had never been physically transferred off the originator's books. This treatment will depend on jurisdiction, but U.S. courts have a history of consolidation rulings. Under this scenario, the goal of isolating the originator from counterparty risk with the SPV is often not realized.

A **derivative product company (DPC)** is an entity that evolved out of a need for over-the-counter (OTC) derivatives markets to manage counterparty risk. They commonly transact in credit default swaps (CDSs), equity derivatives, currency derivatives, and interest rate-based derivatives. A DPC is set up by a financial institution to obtain a AAA credit rating with separate capitalization from the originator. This puts further distance between a DPC and its originator. In this way, if the DPC originator were to fail, then the DPC would not be harmed. This provides a measure of enhanced protection for DPC counterparties.

The credit rating for a DPC depends on three items: minimizing market risk; support from the originator; and internal credit risk management guidelines. In terms of minimizing market risk, a DPC will often remain market-neutral by trading offsetting contracts. Ideally, these mirrored trades will occur on both sides of every trade so the counterparty risk is negligible. Similar to an SPV, a DPC is established to be bankruptcy-remote from the originator. However, in the event of failure of the originator, a DPC is pre-arranged to either pass to another originator or to gradually unwind all mirrored transactions in an orderly fashion. Internal credit risk management guidelines also provide another layer of risk mitigation in a DPC. These restrictions often involve daily marking to market and collateral posting to limit risk exposures.

The concept of an orderly unwinding of a DPC's book does not always hold true in real world application. When both Lehman Brothers and Bear Stearns failed in the 2007–2009 financial crisis, DPCs from these institutions experienced very un-orderly unwindings. Those from Lehman Brothers filed for Chapter 11 bankruptcy, as did their originator, and those from Bear Stearns had to be manually unwound by JPMorgan.

Professor's Note: There is a version of DPC known as a credit derivative product company (CDPC) that exists not only to provide credit derivative protection, but also to profit from offering such protection. The CDPC model carries a great deal of market risk because it does not utilize offsetting risk positions.

A **monoline insurance company (monolines)** is a highly leveraged insurance company with a single business line to insure bond repayments. Their initial purpose was to enhance the credit quality of U.S. municipal issuers, but their pursuit of profit lead them to also offer credit enhancements, in the form of CDSs, for various structured credit products. Unlike a DPC, monolines do not post collateral against their transactions when business conditions are normal and they retain their AAA credit rating. This means that, in a normal state, losses are not formally booked through the marking-to-market process as they are with a DPC. However, if business deteriorates and the monoline's credit rating is downgraded, then they may be forced to post collateral just at the time that their insured losses are mounting.

Professor's Note: MBIA, Inc., is an example of a monoline insurance company. Their ticker symbol is MBI, and their profitability never recovered from the 2007–2009 financial crisis where they incurred many insured losses beyond what their models predicted.

A case can be made that the monoline business model has been flawed from its inception. They operate as centralized entities that absorb systemic shocks by accepting large amounts of counterparty risk. One of the keys to risk mitigation is diversification, and monolines intentionally concentrate their insurance offerings, which works against the natural flow of risk mitigation.

In the wake of the 2007–2009 financial crisis and the failure of the SPV, DPC, and monoline structure of counterparty risk intermediation, the **central counterparty (CCP)** has risen as a solution for systemic risk mitigation. CCPs provide clearing services for many different types of financial transactions between member firms, which means they essentially stand in the middle of previously bilateral OTC transactions and operate as the buyer for every seller and vice versa. Through this process, the original counterparty is no longer a direct risk as the CCP conceptually becomes the new counterparty. Figure 1 shows a traditional bilateral counterparty structure where default risk is directly borne by the individual counterparties.

Figure 1: Bilateral Structure

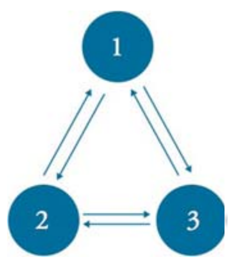
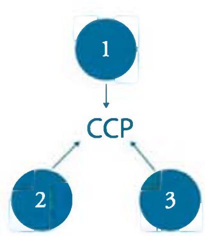


Figure 2 shows how a CCP structure changes the traditional risk landscape with the CCP acting as the middleman in all risk transactions. Through this new structure, a CCP can reduce market interconnectedness because Party 1 is no longer directly exposed to the full losses of Party 2 or Party 3, for example. There is some potential additional complexity as some counterparties do not access a CCP directly but rather through a backchannel using one of the member firms. For example, Party 4 might not be a member firm with a given CCP, but they may still clear financial transactions using Party 3, who is a member firm, as a conduit. This possible scenario will add an additional layer of complexity to a default scenario.

Figure 2: CCP Structure



CCPs remain market-neutral by netting all buy-side transactions with offsetting sell-side transactions. This multilateral netting process requires counterparties to post collateral through a margin account. The end result is less theoretical risk in the system due to the daily, or sometimes intra-daily, mark-to-market collateral system.

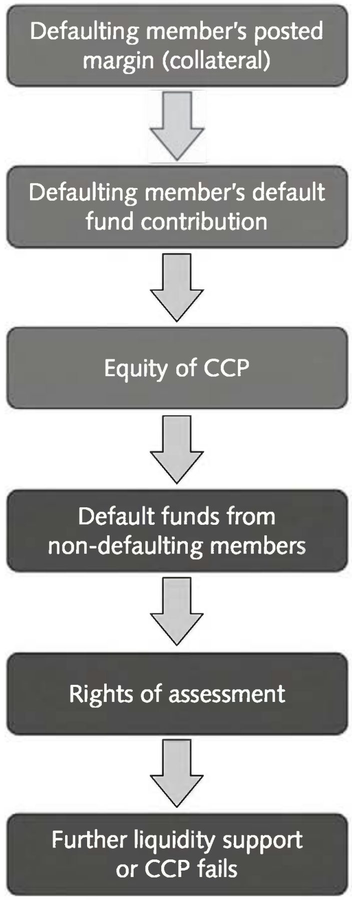
In the event of a default, a CCP must replace non-performing contracts. This process is formally called **novation**, and it involves closing out the non-performing side of a bilateral contract with a new counterparty who is capable of meeting the contractual obligations. If the CCP does need to step in to resolve a defaulted contract, they may need to access default funds that are held on reserve by the CCP and fed by contributions by all member firms. In this way, the losses are mutualized among all member firms by the nature of the CCP's structure. This loss mutualization process spreads any realized losses over a wide number of market participants rather than concentrating them with a singular party.

CCP Risk Management Process

LO 28.2: Describe the risk management process of a CCP and explain the loss waterfall structure of a CCP.

Given the central role that CCPs play in the counterparty risk mitigation system, an effective risk management process is imperative. Should one of a CCP's members default on a transaction, the CCP's goal is to quickly terminate the transaction in an attempt to minimize realized losses. Their first action will be to attempt replacement of the defaulted contract with a valid contract from one of the CCP's other members as the new counterparty. The CCP will try to achieve this by auctioning the defaulted contract to members. Clearing members have an incentive to participate in this auction to work-out the smallest possible loss for the CCP's collective member group. In this way, the CCP structure may yield a higher auction price for defaulted assets than would be achieved in the open market. Any realized losses will be absorbed following the loss waterfall, shown in Figure 3.

Figure 3: CCP Loss Waterfall



The first stage in the loss waterfall is for the defaulting member to sacrifice the collateral that they posted when their transaction was initiated and when daily marking to market occurred. All collateral posted to a CCP is in the form of cash in the currency in which the contracts are denominated. This is a very liquid form of collateral and makes this process as easy as it can be.

The next layer down on the loss waterfall is the defaulting member's default funds. In a perfect world, each member would contribute enough money to the CCP to pay for 100% of their potential losses, but this value could be prohibitively high. Instead of this high standard, members are required to contribute money into the CCP's default fund at a level that would cover potential losses with a high confidence level.

After the collateral and the default fund contributions from a defaulting member have been exhausted to remedy a realized loss, the CCP will dip into its own equity capital to a point where the CCP would still be able to function normally. If a loss still remains after these options have been exhausted, then the loss mutualization process takes over. The first layer of this process is to utilize contributions to the CCP's default fund from the non-defaulting members. In extreme loss situations, member firms may need to make additional contributions to the default fund to prevent the CCP from total liquidation and collapse. These additional contributions are known as rights of assessment. If the needs of a CCP are significant, then it could be detrimental to the survival of the member firms. In this case,

the CCP will either fail or require external liquidity support from a well-capitalized entity like a central bank. Full movement down the loss waterfall is an extremely low probability event.

Bilateral and Centrally Cleared OTC Derivatives

LO 28.3: Compare bilateral and centrally cleared over-the-counter (OTC) derivative markets.

The notion of a centrally cleared OTC derivatives market is best considered in contrast to a bilateral market. Several key characteristics of each are summarized here.

Key characteristics of bilateral markets include:

- *Counterparty*. In a bilateral market, the original counterparty remains in effect as long as the contract remains in effect.
- *Available products*. There are no limitations to products that can be utilized in bilateral markets. As long as the two parties agree to the terms of a contract, then it is able to be created.
- *Contract netting*. Any netting of contracts to offset risks will need to be manually and intentionally arranged by players in bilateral markets. Typically, trades are not offset as market participants are placing bets on specific events, which means they do not wish to be market-neutral.
- *Eligible participants*. Participation in bilateral markets is open to any and all market actors. The only exclusion would be if someone has such weak credit that no counterparty would be willing to take the opposite side of their trade.
- *Concentration of counterparty risk*. All contracts are willingly engaged between two bilateral parties. Through this process of self-selection, counterparties can actively choose to limit the risk of exposure to a given party.
- *Collateral*. Two bilateral counterparties are able to negotiate customized collateral arrangements. New regulatory rules are trying to standardize this factor, but for now, there is a great deal of flexibility.
- *Close-out of default positions*. Close-out of a default position can be messy in a bilateral market. This process is entirely between two bilateral counterparties and may quickly result in a default scenario for the entire counterparty and not just the isolated transaction.

Key characteristics of centrally cleared markets include:

- *Counterparty*. In a centrally cleared market, the original counterparty is effectively replaced when the CCP steps into the middle of the transaction. Through the CCP structure, the CCP becomes the new counterparty and the other CCP members become secondary counterparties.
- *Available products*. Financial products traded in centrally cleared markets must be standard, plain-vanilla (non-exotic), and liquid. This helps to limit loss potential from specialized contracts, but it also limits the flexibility of types of contracts that can be engaged in within the CCP structure.
- *Contract netting*. CCPs naturally try to remain market-neutral by netting financial transactions. This process helps to further spread out risk.

- *Eligible participants*. Centrally cleared markets are only open to clearing members, which are typically large financial institutions. Other entities may clear transactions by using a clearing member as a conduit only if they are willing and able to post the necessary collateral and a clearing member is willing to sponsor them.
- *Concentration of counterparty risk*. Since clearing members have a measure of protection to transact within the construct of a CCP, this does create an incentive for concentration of risk positions whereby a given CCP will see a meaningful percentage of the transactions for a given member firm.
- *Collateral*. A centrally cleared market has transparent collateral requirements and margin rules with daily or intra-daily posting. These rules are static and non-negotiable for member firms.
- *Close-out of default positions*. A coordinated default process is one of the hallmarks of a centrally cleared market. The loss waterfall is the heart of this process, and it has the potential to not let a default on a single asset result in the complete default of an individual member firm. This coordinated close-out structure helps to minimize internal costs due to operational efficiencies and also minimize legal risk because the member firms are already engaged in a rules-based transactional relationship.

CCP Advantages and Disadvantages

LO 28.4: Assess the capital requirements for a qualifying CCP and discuss the advantages and disadvantages of CCPs.

Because a CCP is not risk-free, there are two specific capital charges that are applied to this system. The first capital charge is for *trade exposure*. This risk arises from the mark-to-market process along with potential future mark-to-market margin contributions that may be required. This exposure has a relatively small risk weight of 2%. The second capital charge is for *default fund risk exposure*. This risk comes directly from the loss waterfall whereby a member's default fund contributions might be forfeited, non-defaulting members could have their default fund contributions captured due to the default of a member firm, and additional default funds may need to be raised using rights of assessment. This risk is very difficult to quantify, and it gets even more difficult because each CCP sets default contributions internally. The current system for default fund risk exposures is a baseline one-to-one capital charge. Anticipated rules may lessen this burden in the near future.

The financial crisis of 2007–2009 demonstrated the ability of a CCP to efficiently mitigate the downside risk of the failure of a large financial institution. However, the CCP structure is a relatively new market enhancement and its long-term impact is still unknown. While the centralized clearing process does not fully eliminate counterparty risk, it does greatly reduce it from a traditional bilateral model. The advantages and disadvantages of the CCP structure are summarized here.

The advantages of a CCP include:

- **Transparency**. Unlike bilateral markets, a CCP can see aggregate risk concentrations because they are aware of many of the transactions of their member firms. This enables the CCP structure to potentially offset risks that it notices.
- **Multilateral netting**. The transparency of the CCP structure enables risk to be offset. The netting process eliminates the need for members to monitor the creditworthiness of other members. This process also lowers margin costs for member firms.

- **Liquidity.** Daily collateral settling leads to enhanced market transparency and therefore improved market liquidity.
- **Legal and operational efficiency.** Both netting and the collateral policies of a CCP increase operational efficiency and lower costs. Legal costs are also minimized due to the rules-based structure of a CCP.
- **Loss mutualization.** In the event that a CCP member defaults, the CCP will manage the default using the loss waterfall where realized losses may be shared by all members of the CCP. This reduces the market impact of a default scenario.
- **Default management.** The CCP also manages default scenarios with an orderly auction of the defaulted member's position. This brings stability to the market and secures the best price possible for the market.

The disadvantages of a CCP include:

- **Moral hazard.** This well-known insurance industry concept can be applied to the CCP structure because there is little incentive for member firms to vet the creditworthiness of other member firms. The netting, collateralization, and loss mutualization process contribute to this view.
- **Adverse selection.** Most CCP member firms specialize in derivatives contracts. As such, they may have superior knowledge on pricing and risk compared to the CCP. This creates an environment where the member firms may choose to trade with CCPs that offer the best prices due to incomplete information.
- **Bifurcations.** The fact that CCPs are required to only clear standard contracts has created a bifurcated market where some trades are processed through clearing firms and some are not. This creates risks for the system.
- **Procyclicality.** Procyclicality refers to a positive correlation between an event and the state of the economy. As the market and economy become more volatile, CCPs generally increase collateral requirements, which can further exacerbate a potential default scenario.

The Impact of Central Clearing

LO 28.5: Discuss the impact of central clearing on credit value adjustment (CVA), funding value adjustment (FVA), capital value adjustment (KVA), and margin value adjustment (MVA).

During the 2007–2009 financial crisis, a good portion of the counterparty losses were not from direct defaults, but rather were from the impact of credit market volatility on bank earnings. As a result, Basel III established a **credit value adjustment (CVA)** charge to improve resilience to counterparty mark-to-market losses. The CVA is essentially a discount offered by a derivatives buyer to account for counterparty default potential. The use of centrally cleared CCPs greatly reduces counterparty risk and therefore reduces the CVA.

Funding value adjustment (FVA) charges are costs associated with uncollateralized OTC derivatives contracts. Because CCPs require highly liquid collateral, traditional FVA charges are reduced by using a CCP structure.

Regulators require that banks hold capital reserves to survive significant and unexpected credit risk events. When banks hold OTC derivatives contracts, the additional capital

charge is called the **capital value adjustment (KVA)** charge. When a CCP is used to help insulate a bank from substantial losses, the KVA charge is reduced.

Margin value adjustment (MVA) charges are related to direct costs of posting margin collateral on OTC derivatives contracts. Because CCPs require initial margin postings and daily marking to market (variation margin postings), the MVA costs have increased due to the centrally cleared CCP structure.

Key Concepts

LO 28.1

A special purpose vehicle (SPV) is a bankruptcy-remote legal entity designed to hold structured products. The default of an SPV could cause default for the originator as well. A derivative product company (DPC) is setup very similarly to an SPV, but it is one more step removed from the originator to help isolate risk in a default scenario. Monoline insurance companies provide insurance for only one type of product. Default on insured products could create a going-concern issue for monolines. Central counterparties (CCPs) are entities that step into the middle of a bilateral counterparty relationship and offset risk in several ways, including loss mutualization, collateral posting, and multilateral trade netting.

LO 28.2

Central counterparties utilize a loss waterfall to mutualize losses among all member firms. At the top of the sequence is the defaulting firm losing its collateral and default fund contributions. After that, the CCP will cover some losses out of its own equity before tapping the default fund contributions of non-defaulting members.

LO 28.3

Bilateral counterparties must vet each other's creditworthiness before they transact in any form of financial transaction that they wish to customize. A default scenario can be a messy affair as it is up to the two counterparties to figure things out and hopefully not create a systemic event, which can happen. Centrally cleared counterparties only transact in standard contracts with member firms, so vetting of creditworthiness is less vital. CCPs offer trade netting and standardized collateralization. A default scenario with a CCP can be very orderly and minimize systemic risk shocks due to the loss mutualization process inherent in their structure.

LO 28.4

The advantages of a CCP include transparency, multilateral netting, liquidity, legal and operational efficiency, loss mutualization, and an orderly default management process. The disadvantages of a CCP include moral hazard, adverse selection, a bifurcated market, and procyclicality.

LO 28.5

The centrally cleared counterparty structure will reduce credit value adjustment (CVA) charges, funding value adjustment (FVA) charges, and capital value adjustment (KVA) charges. It will increase margin value adjustment (MVA) charges.

Concept Checkers

1. Which of the following statements is an enhancement offered by the central counterparty (CCP) structure relative to the special purpose vehicle (SPV), the derivative product company (DPC), and the monoline insurance models?
   A. The CCP structure enables financial institutions to remove assets from their balance sheets.
   B. The CCP structure enables counterparty risk to be outsourced, but in a non-diversified format.
   C. The CCP structure spreads losses over a group of counterparties to minimize potential systemic risk.
   D. The CCP structure enables a counterparty transaction originator to fail and not affect the other member firms.

2. Given the following three events, what is the proper order of the loss waterfall?
   I. Non-defaulting member's default fund contributions are exhausted.
   II. Defaulting member's collateral and default fund contributions are exhausted.
   III. CCP taps an amount of its equity that enables them to function normally.
   A. I, II, III.
   B. II, III, I.
   C. II, I, III.
   D. III, II, I.

3. Which of the following statements is not an improvement that centrally cleared markets offer relative to bilateral markets?
   A. Centrally cleared markets improve the counterparty risk picture by replacing the original counterparty with a series of counterparties.
   B. Centrally cleared markets remain market-neutral by netting trades.
   C. Centrally cleared markets formalize the default work-out process by utilizing a loss waterfall structure.
   D. Centrally cleared markets offer more flexibility in contract selection because of their collateral collecting process.

4. Which of the following actions is not an advantage of the CCP in the centralized clearing process?
   A. Risk reduction through multilateral netting.
   B. Eliminate counterparty risk.
   C. Improved operational efficiency.
   D. Loss mutualization.

5. Which of the following capital charges would the CCP structure increase?
   A. Funding value adjustment (FVA) charges.
   B. Margin value adjustment (MVA) charges.
   C. Capital value adjustment (KVA) charges.
   D. Credit value adjustment (CVA) charges.

Concept Checker Answers

1. **C** Through the collateralization and the loss mutualization processes, a CCP does spread losses over a group of counterparties and in the process reduces potential systemic risk. SPVs and DPCs are the entities that remove assets from a financial institution's balance sheet. Monoline insurance companies enable counterparty risk outsourcing in a non-diversified format. In the event that a counterparty transaction originator fails in the CCP structure, then all member firms are impacted through the loss waterfall. It is the DPC that protects itself from failure of the transaction originator.

2. **B** The first layer in the loss waterfall is for the defaulting member's collateral and default fund contributions to be exhausted. The next layer is for the CCP to tap into its own equity to the point where it could still function normally. Then, non-defaulting members will have their default funds exhausted before moving to the rights of assessment.

3. **D** Bilateral markets permit any type of customized financial contract and customized collateral that is freely negotiated between the two bilateral parties. In a centrally cleared market, flexibility is reduced because contracts must be standardized and collateral rules are fixed and non-negotiable.

4. **B** The centralized clearing process utilized by a CCP does not eliminate counterparty risk, but it does greatly reduce this risk relative to a traditional bilateral transaction.

5. **B** The CCP structure should reduce credit value adjustment (CVA) charges, funding value adjustment (FVA) charges, and capital value adjustment (KVA) charges. It will increase margin value adjustment (MVA) charges. The reason for the MVA increase is that there is a higher margin requirement with a CCP than with a bilateral counterparty transaction.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Default Probabilities, Credit Spreads and Funding Costs

Topic 29

Exam Focus

This topic discusses the theory of default probability and its practical application to credit spreads and credit derivatives. For the exam, be able to explain the difference between cumulative and marginal default probabilities. Also, be able to calculate risk-neutral and real-world default probabilities in pricing derivative contracts. Finally, understand how recovery rates are estimated, and the underlying mechanics of credit default swaps (CDS) and portfolio credit derivatives.

Default Probability

LO 29.1: Distinguish between cumulative and marginal default probabilities.

The **cumulative default probability**, *F(t)*, represents the likelihood of counterparty default between the current time period and a future date, *t*. Intuitively, the cumulative probability of default must be an increasing function. Further, the probability of default at the current point in time can be interpreted as zero and increases over time, reaching a maximum of 100%, which implies that all counterparties will eventually default. That is, given a sufficiently long period of time, some unforeseen event or extreme economic circumstance will cause even the most creditworthy companies to become insolvent.

The **marginal default probability** denotes the likelihood of counterparty default between two future points in time denoted t_1 and t_2. Marginal default probabilities must be non-negative to make economic sense. In equation form, marginal default probability can be expressed as follows:

$$q(t_1, t_2) = F(t_2) - F(t_1)$$

where:
$t_1 \leq t_2$

Risk-Neutral vs. Real-World Default Probabilities

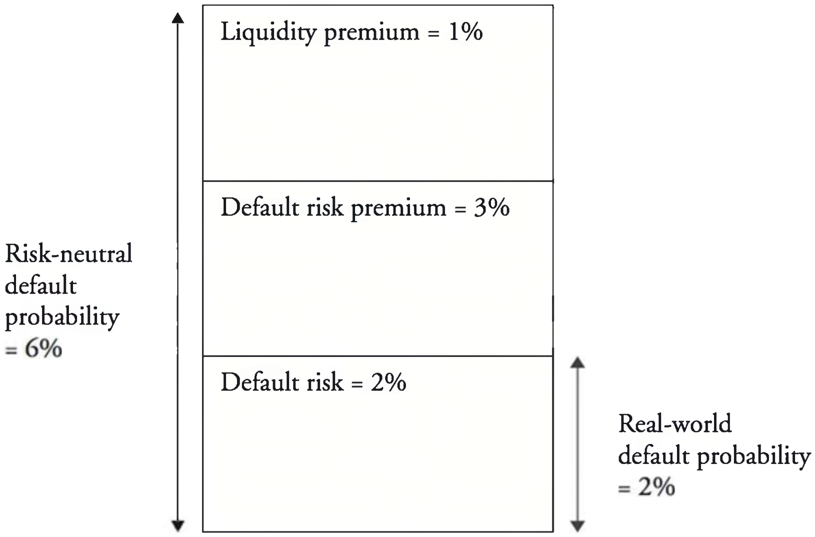
LO 29.2: Calculate risk-neutral default probabilities, and compare the use of risk-neutral and real-world default probabilities in pricing derivative contracts.

Risk-neutral default probabilities are calculated from market information, while **real-world default probabilities** are based on historical data. Typically, real-world default probabilities are less than risk-neutral default probabilities. Although the difference between risk-neutral and real-world default probabilities may seem to be just semantics, the difference is extremely important.

Risk-neutral default probabilities represent the estimated parameter value determined from an observable market price. If the pricing model is assumed correct, the unknown parameter can be determined by solving for the parameter value that makes the model price equal to the market price. A good example is the implied volatility from an observed option price using the Black-Scholes-Merton model. The risk-neutral probability of default is the estimated parameter value that forces the observed pricing model to equal the market price. However, there may be other factors in addition to real-world default probability, such as a liquidity or default risk premium that are aggregated into the risk-neutral default probability calculation. Hence, the risk-neutral default probability is likely to overstate the actual probability of default.

A simple numerical example can further illustrate this point. Suppose there is a one-period, zero-coupon bond that will mature with face value of \$100. The obligation will default with 2% probability. For simplicity, assume no recovery in the event of default. This scenario is illustrated in Figure 1. Ignoring the time value of money, the expected value of the cash flows would be (\$100 × 0.98) + (\$0 × 0.02) = \$98. However, a rational investor would never pay \$98 because there is chance of zero recovery due to default. Hence, the investor will price the bond lower at, for example, \$95 to compensate for the uncertainty of the return. This \$3 reduction represents the **default risk premium**. Further, suppose the investor feels that market conditions may impact the ability to sell the bond in a timely fashion and imposes an additional \$1 reduction (i.e., **liquidity premium**) for such liquidity concerns. The final price is then \$94. Because \$94 is the observed market price, the risk-neutral probability of default is computed as 6%, which is in sharp contrast to the actual real-world probability of default of 2%.

Figure 1: Default Probabilities



The risk-neutral probability can be displayed in equation form as follows:

risk-neutral default probability = liquidity premium + default risk premium + real-world default probability

It is important to note the appropriate use of each calculation. The real-world default probability (i.e., actual probability of default by a counterparty) should be incorporated into quantitative risk and return assessment conducted during the risk management process. Risk-neutral default probabilities should be incorporated into hedging decisions because they are derived from actual market prices.

Estimation Approaches

LO 29.3: Compare the various approaches for estimating price: historical data approach, equity based approach, and risk neutral approach.

Historical Data Approach

The most direct assessment of default probabilities is to use historical default data to forecast future default probabilities. In this case, a transition matrix is helpful in calculating default probabilities because it identifies the historical probabilities of credit rating migration between periods. Cumulative default probabilities can be estimated by matrix multiplication of the transition matrix with itself. This methodology assumes the transition matrix is constant over time and hence unaffected by the business cycle, an observation not supported by empirical evidence. In general, credits are more likely to be downgraded than upgraded. In addition, the cumulative probability of default for investment-grade credits increases more rapidly than for noninvestment grade credits over a given period. This is simply a case of mean-reversion.

Equity-Based Approaches

Equity-based approaches for estimating real-world default probabilities include the Merton model, the KMV approach, and CreditGrades™. Equity-based approaches allow for a dynamic estimation of default probability as opposed to the static estimate provided by the historical approach.

The **Merton model** uses equity market data to estimate default probabilities. In this model, the equity value is viewed as a call option with a strike price equal to the firm's debt level. This model assumes the firm has a single-period, zero-coupon bond outstanding and hence can only default at maturity. Therefore, the estimation of default probabilities is reduced to assessing where the firm's asset value will fall below its outstanding debt level.

The **KMV approach** uses a proprietary approach built on the Merton model, but it relaxes several of its assumptions. The steps to the KMV approach are as follows: (1) volatility and market value estimates are calculated, (2) the **distance to default** (the number of standard deviations between current asset values and the debt repayment amounts) is calculated, and (3) historical default data and distance to default are used to estimate the expected default probability.

CreditGrades™ uses observable market data and balance sheet information to create a model that is simpler (due to fewer model parameters) and easier to replicate than other equity-based approaches. Importantly, empirical data is not utilized in this model.

Risk-Neutral Approach

The risk-neutral probability of default is derived from the observed credit spread and the market price of a traded credit security. In practice, this is challenging because there is no single credit spread but several possible estimates, including credit default swap (CDS) premiums, bond prices relative to a benchmark Treasury curve, and spreads on asset swaps.

To model this process, consider a credit with a constant 9% probability of default per year. Hence, the default probability in the first year is 9%, 8.2% in year 2 [= probability of no default in prior year × probability of default in current year = (100% – 9%) × 9% = 91% × 9%], 7.5% in year 3 (= 91% × 91% × 9%), and so on. It follows that the cumulative default probabilities for these periods are 9%, 17.2%, and 24.6%, respectively, and that the conditional default probability (i.e., the default probability in a period assuming no default in prior periods) is 9%.

Using the Poisson process, the default probability for future time period u is expressed as follows:

$$F(u) = 1 - \exp(-h \times u)$$

where h is the hazard rate of default (i.e., the default probability for an infinitesimally small time period).

Professor's Note: The notation exp(x) *is equivalent to* e^x. *Therefore, use the exponential function on your calculator for these calculations.*

For example, assume h = 4.7% and u = 2. In this case, default probability can be solved as follows:

$$9\% = 1 - \exp(-0.047 \times 2)$$

This result matches the previous discrete example very closely. Utilizing the observation that h ≈ spread / (1– recovery) yields the approximate formula for risk-neutral probability:

$$F(u) = 1 - \exp\left[-\frac{\text{spread}}{1 - \text{recovery}} \times u\right]$$

While this derivation is simple and elegant, a significant problem remains, namely, two parameters (recovery rate and probability of default) must be estimated based on only one observation of the credit spread. Standard procedure is to assume a fixed recovery rate, typically around 40%, to derive market-based default probabilities.

Finally, the marginal probability of default can be approximated as:

$$q\left(t_{i-1}, t_i\right) \approx \exp\left[-\frac{\text{spread}_{t_{i-1}}}{1 - \text{recovery}} \times t_{i-1}\right] - \exp\left[-\frac{\text{spread}_{t_i}}{1 - \text{recovery}} \times t_i\right]$$

Empirical evidence indicates that risk-neutral default probabilities are significantly larger than real-world default probabilities. Perhaps counterintuitively, the difference is larger for higher-quality credits and has meaningful impacts on hedging. For practical purposes, real-world default probabilities are more appropriate if counterparty risk is ignored (or considered negligible). Conversely, if one wants to hedge against counterparty risk, then risk-neutral probabilities must be considered.

Recovery Rates

LO 29.4: Describe how recovery rates may be estimated.

Recovery rates refer to the percentage of par (i.e., notional) value that is realized (i.e., recovered) after default. Generally, ex-ante recovery rates are not directly observable because credit products are priced jointly, factoring in default probabilities and recovery rates. Hence, the calculation of one depends on an estimate of the other.

In a perfect world, recovery rates would be derived from observed market prices of **recovery swaps** where the counterparties agree to pay/receive the difference between ex-post actual recovery and ex-ante agreed-upon fixed recovery rate. The problem is that these swaps are not typically traded.

As an alternative, historical recovery rates from defaulted securities can be utilized. This simple approach is complicated by several factors. First, recovery rates vary by industry and time periods. That is, there is strong evidence of clustering of defaults during economic downturns and, within a given industry, generally lower recovery rates. Second, higher default rates have a negative relation with recovery. In other words, recovery amounts tend to be lower during periods of above-average defaults. Third, recovery rates are clearly related to the capital structure whereby more senior claims will have higher recovery rates than subordinated or junior claims. Fourth, the potentially long, drawn-out process in bankruptcy proceedings can lead creditors to selling claims prematurely in the market. Hence, the realized (settled) recovery may be different than the eventual (actual) recovery.

Credit Default Swaps

LO 29.5: Describe credit default swaps (CDS) and their general underlying mechanics.

The most well-known credit derivative is the **credit default swap** (CDS). The CDS is an insurance-like security that transfers credit risk from the protection buyer to the protection seller for a pre-specified premium. The contract must specify the reference entity (e.g., corporate credit, sovereign borrower), reference obligation, settlement procedures, and the notional amount of protection. Note that the reference entity is not a counterparty in the CDS. In addition, the CDS must specify the universe of credit events (e.g., bankruptcy, insolvency, restructuring) for the reference entity that will trigger a payment from the party long the credit risk to the party short the credit risk at the initiation of the agreement.

The dramatic rise in popularity of CDS contracts throughout the 2000s led to some standardization of CDS contracts. Typically, high-quality issuers will trade with fixed coupons of 100 bps per annum while high-yield issuers will trade with coupons of 500 bps per annum. An additional up-front, one-time payment may be made from the buyer of protection to the seller of protection (or vice versa) if the actual premium is higher or lower than the fixed coupon.

In case of default, CDS may settle in physical terms or in cash terms. For physical settlement, the required number of bonds with par value equal to the notional is delivered to the counterparty in exchange for a cash payment also equal to the notional principal. This method requires the protection buyer to physically deliver the bonds. Hence, if the buyer does not actually own the bonds, the buyer will have to purchase them in the open market. This creates an additional risk that the sudden demand for the defaulted securities will raise the price as many protection buyers will need to purchase the bond. This event is known as a **delivery squeeze**. However, an advantage of physical delivery is that there is no need to determine the size of the loss because the full notional is transferred in default.

The cash settlement for default has some important differences relative to physical settlement. Because the bonds are not transferred from the protection buyer to the protection seller under cash settlement, there is no need to own or purchase the defaulted securities. Rather, the protection seller makes a single compensatory payment of par (i.e., the post-event market price). A problem arises because the market price is fluid based on the demand for the defaulted debt. To further standardize the process, an auction is held approximately 30 days after default, at which point the settlement price is determined.

The Credit Spread Curve

LO 29.6: Describe the credit spread curve and explain the motivation for curve mapping.

The **credit spread curve** is essentially a yield curve of credit spreads for different maturities. The first step to creating the curve is to plot the most liquid credit spreads observable in the market for a single credit or credit rating, generally from CDS premiums or bond spreads, for all available maturities. While this concept is appealing, implementation is challenging because of data limitations. Even if the aforementioned securities (across several maturities) have sufficient liquidity, there are still many gaps in the curve that require a subjective estimation procedure to generate a smooth curve.

Plotting the curve is further complicated by the choice of reference. For example, construction of a AA-rated credit curve would have a relatively large choice of securities to infer credit spreads. Conversely, a more narrowly defined credit curve based on a particular industry sector or geography would limit the available data points, introducing more subjectivity into the curve.

An alternative method uses the credit spread around a single, liquid observation (e.g., credit spread with five years to maturity) to map the entire curve. For illustration, suppose the relevant five-year bond yield is 6%, and the maturity-matched benchmark is yielding 5%. This observation is considered to be one data point on the "mapped" credit curve. The remaining points on the credit curve are "mapped" by adjusting the index upward for all other maturities. In our example, the entire mapped curve would be estimated to be 120% of the index curve. A secondary question raised is the identification of an appropriate index.

Portfolios of Credit Derivatives

LO 29.7: Describe types of portfolio credit derivatives.

Credit derivatives can be combined into portfolios to form new products. The most popular of these products is the CDS index, which is typically structured as an equally weighted index of the underlying credit default swaps. Interestingly, the CDS index will not price exactly as an equally weighted basket of the underlying credits due to institutional factors such as variation in the bid-offer, credit event triggers, and up-front payments.

Index composition varies based on geography (e.g., North American, European, Asian markets) and other factors such as maturity. The two most popular (and liquid) indices are the CDX NA IG and iTraxx Europe. Both indices consist of 125 equally weighted, investment grade CDSs, with the primary difference being that the CDX NA IG uses North American entities and the iTraxx Europe uses European entities.

In contrast to traditional indices such as the S&P 500, CDS indices are created with a fixed maturity and static constituents. That is, if there is a significant credit event, the affected credit entity will be removed from the index and replaced with another name that meets the requirements. The index will continue to trade based on the remaining non-defaulted

credits, and the new notional principal of the index would be based on the remaining entities.

In addition, credit indices roll every six months. That is, a new on-the-run CDS index series is created every six months with new constituents based on credit events, rating changes, and CDS premium changes. However, previous index series continue to trade. Series maturities are typically five, seven, and ten years, with the five-year index being the most popular. The goal is to ensure that the newly created indices are homogenous with the overall credit quality of the previous portfolio and reflective of current market conditions. Lastly, the indices trade with a fixed coupon (e.g., 100 bps for investment grade indices and 500 bps for speculative grade indices), which simplifies the trading and marking to market of the indices.

LO 29.8: Describe index tranches, super senior risk, and collateralized debt obligations (CDOs).

Index tranches create a capital structure for the credit index whereby the entire loss distribution is divided into mutually exclusive ranges. The losses are absorbed sequentially by the equity, mezzanine, senior, and super-senior tranches. Each tranche is described by its attachment point (X%) and detachment point (Y%), denoted [X%, Y%], and the width of each tranche is Y% – X%. It follows that the subordination level for each tranche is X%. That is, there is no loss experienced by the tranche until X% of losses has occurred in the index. Lower-level tranches receive higher returns and possess higher risk than higher level tranches. Lastly, the CDX NA IG and iTraxx Europe have predefined equity tranche levels of 0% – 3%, but they differ on the size of the mezzanine and senior tranches.

Super-senior tranches represent the portion of the capital structure for credit indices that has the highest subordination level and lowest probability of incurring losses. Informally, these tranches are termed *super triple-A* and *quadruple A tranches* to distinguish their lower relative risk from AAA-rated tranches. For practical purposes, the likelihood of sufficient defaults to reach the super-senior attachment point is highly unlikely. To gain some insight into this process, the required defaults to breach a tranche with a subordination level of X% can be expressed in general form by:

$$\text{number of defaults} = n\left(\frac{X\%}{1 - \text{recovery}}\right)$$

Note that both the subordination level and recovery rate assumptions are implicit in this calculation. As an illustration, suppose a super-senior tranche has an attachment point of 30% (which happens to be the subordination level for CDX), 100 underlying credits, and an assumed recovery rate of 40%. This tranche will require 50 defaults to cause economic loss to the super-senior tranche, shown as follows:

$$\text{number of defaults} = 100\left(\frac{30\%}{1 - 40\%}\right) = 50$$

In summary, the probability of impairments to the super-senior tranche is extremely small due to the high level of subordination. Hence, the credit risk of these tranches is not a major concern. The primary risk of these tranches is counterparty risk (termed *super-senior*

risk) as this risk is positively correlated to tranche seniority. That is, higher seniority tranches have higher levels of counterparty risk. Unfortunately, it is nearly impossible for institutions to efficiently hedge this super-senior risk.

Collateralized debt obligations (CDOs) can be thought of as customized baskets of debt instruments segmented broadly into senior, mezzanine, and equity tranches. Because the underlying portfolio is not necessarily equally weighted, the specific tranche attachment and detachment points are not standardized, but similar to index tranches, the credit risk is concentrated in the equity tranche and the senior tranches are unlikely to suffer losses.

CDOs are typically divided into two broad categories: synthetic CDOs and structured finance securities. **Synthetic CDOs** are custom-made instruments for a specific transaction. From a trading perspective, each tranche may trade separate from the rest of the capital structure. **Structured finance securities**, including collateralized loan obligations (CLOs), mortgage-backed securities (MBSs), cash CDOs, and related instruments, typically involve more complex waterfall structures to determine payouts to different tranches. As a result, the individual tranches cannot be traded separately.

Key Concepts

LO 29.1

Cumulative default probability is the probability a counterparty will default before time *t*. The cumulative default probability function, *F(t)*, increases over time, eventually reaching 100%. The marginal default probability is the probability of default between two future dates: $q(t_1, t_2) = F(t_2) - F(t_1)$, where $t_1 \leq t_2$.

LO 29.2

Risk-neutral probabilities represent estimates of default probability based on observed market prices of securities (e.g., bonds, credit default swaps). However, the market price aggregates actual real-world default probabilities with credit premiums, liquidity discounts, and possibly other factors. Hence, the risk-neutral probability overstates the actual real-world default probability. Risk-neutral probabilities are useful for hedging considerations, while real-world default probabilities are useful for quantitative risk assessment.

LO 29.3

There are three approaches to estimate default probabilities: (1) the historical data approach, (2) equity-based models (Merton, KMV, and CreditGrades™), and (3) the risk-neutral approach. Historical data uses transition matrices based on historical credit migration and is limited by the static nature of the data. Equity models view firm equity as a call option with a strike price equal to debt level. Risk-neutral models use observed credit spreads to estimate hazard rates used in a Poisson process. An important limitation is that market-observed spreads jointly factor into default probability and recovery rate (i.e., an implicit recovery rate must be assumed).

LO 29.4

Recovery rates represent the percentage of principal available to creditors after default. Recovery rates depend on overall market conditions, industry, and seniority in the capital structure. Historically, there is a strong negative correlation with default frequency and recovery rates.

LO 29.5

Credit default swaps (CDSs) are liquid contracts that transfer credit risk from protection buyers to protection sellers. Predefined credit events include bankruptcy, insolvency, and restructuring to reduce post-event disputes. Settlement may be physical (i.e., deliver par value of notional principal in exchange for cash payment in the amount of notional principal) or in cash (cash transfer from seller to buyer of protection). Premium payments are fixed (e.g., 100 bps for strong credits and 500 bps for weak credits), plus a one-time, up-front payment to adjust for the specific credit quality of the reference entity.

LO 29.6

The credit spread curve is a term structure plot of credit spreads against maturity. The lack of liquid securities may create large gaps in the curve. The mapped curve can be created via estimation techniques or by adjusting a chosen index upward to match the credit spread of a single, liquid observed credit.

LO 29.7

Credit derivatives can be structured into portfolios to simplify trading and marking to market of broad credit movements. Indices are equally weighted, have fixed maturity, and trade with fixed coupons (e.g., 100 bps for high-quality issuers and 500 bps for high-yield issuers). In addition, standardized indices, such as the CDX NA IG and iTraxx Europe, potentially reconstitute their indices every six months.

LO 29.8

Index tranches are standardized slices of the capital structure from a portfolio of CDSs. The tranches have predefined attachment and detachment points where equity, mezzanine, and senior tranches represent increasingly safe securities. Super-senior tranches represent the safest portion of the capital structure in a securitization. While the risk of default for super-senior tranches is low, counterparty risk is a concern. Collateralized debt obligations (CDOs) are pools of credits and can be separated into synthetic (custom-made tranches) CDOs or structured finance securities, including MBSs, CLOs, and similar instruments (rules-based cash flow distribution).

Concept Checkers

1. Which of the following statements about cumulative and marginal default probabilities is most accurate?
   A. Both functions increase over time.
   B. Neither function increases over time.
   C. Only the cumulative default probabilities increase over time.
   D. Only the marginal probabilities increase over time.

2. Based on the following information, what are the the risk-neutral and real-world default probabilities?
   - Market price of bond is 92.
   - Liquidity premium is 1%.
   - Credit risk premium is 2%.
   - Risk-free rate is 2.5%.
   - Expected inflation is 1.5%.
   - Recovery rate is 0%.

	Risk-neutral probability	Real-world probability
A.	5%	8%
B.	8%	5%
C.	6%	8%
D.	5%	6%

3. Robin Hudson, FRM, was discussing the various methods to estimate default probabilities with her colleague Kate Alexander, FRM. Hudson made the following comments:
   I. Transition matrices are an important component of the risk-neutral approach.
   II. Hazard rates measure the instantaneous conditional default probability.
   III. Risk-neutral default probabilities are downward biased estimates of real-world default probabilities.

   How many of these statements should Alexander agree with?
   A. None of the statements.
   B. One statement.
   C. Two statements.
   D. Three statements.

4. Which of the following statements is most likely correct about recovery rates?
   A. Recovery rates vary inversely with capital structure seniority.
   B. Historical recovery rates are fairly constant across industries.
   C. Recovery rates are highest during economic downturns.
   D. Actual recovery rates may differ substantially from settled recovery rates.

5. Which of the following statements about credit default swaps is most accurate?
   A. CDSs transfer credit risk and market risk from the protection buyer to the protection seller.
   B. CDSs transfer credit risk from the protection buyer to the issuer of the underlying credit.
   C. Physical settlement requires knowledge of the post-default market price.
   D. Cash settlement avoids the problem of a delivery squeeze.

Concept Checker Answers

1. **C** The cumulative default probability function begins at zero and eventually reaches 100% and must therefore increases over time. Marginal probabilities of default are always positive but are not necessarily increasing over time.

2. **B** The risk-neutral default probability is approximately 8% because the market price is 92% of par.

   risk-neutral probability = real-world probability + credit risk premium + liquidity premium

   8% = real-world probability + 2% + 1%

   real-world probability = 8% – 3% = 5%

3. **B** Only statement II is correct. Transition matrices are more likely to be used in the historical approach. Empirical evidence shows that real-world default probabilities are significantly lower than risk-neutral default probabilities.

4. **D** Settled recovery occurs fairly soon after the credit event (e.g., CDS auction or sale of defaulted bond), while actual recovery can occur years later based on the bankruptcy resolution. Recovery rates increase with capital structure seniority, are lowest during economic downturns, and vary significantly across industries.

5. **D** One advantage of the cash settlement procedure is that no securities are actually traded so the risk of delivery squeeze (i.e., rising price as protection buyers purchase reference entities in the open market) is negligible.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Credit and Debt Value Adjustment

Topic 30

Exam Focus

The pricing of counterparty risk is a function of the credit exposure and default probability of a counterparty. For the exam, know how to calculate a credit value adjustment (CVA) in the presence of unilateral contracts. Also, understand the concepts of incremental and marginal CVA and know how to estimate CVA as a spread.

Pricing Counterparty Risk

LO 30.1: Explain the motivation for and the challenges of pricing counterparty risk.

The pricing of counterparty risk (i.e., how much to charge a counterparty for the risk that it may default) is a function of the credit exposure and default probability of a counterparty. Accurate pricing of a counterparty's risk generates reserves to absorb potential losses due to that counterparty's default. Pricing counterparty risk needs to account for risk mitigants (e.g., netting, collateralization).

The price of counterparty risk approximates to the value of the risk of all outstanding positions with a counterparty and exists in addition to the price of the financial instrument itself that the counterparties use (e.g., a swap). Best practices will organize responsibilities as to who should calculate counterparty risk within the financial institution. The challenge in pricing this type of risk arises with bilateral derivatives contracts (e.g., swaps with fixed and floating components) rather than one-way payment instruments such as bonds.

Credit Value Adjustment

LO 30.2: Describe credit value adjustment (CVA).

LO 30.3: Calculate CVA and the CVA spread with no wrong-way risk, netting, or collateralization.

The **credit value adjustment** (CVA) is defined as the expected value or price of counterparty credit risk. A positive value represents a cost to the counterparty that bears a greater propensity to default. A risky security transaction has a risk-free price with no counterparty risk and an adjustment for counterparty risk (i.e., risky value = risk-free value – CVA).

The adjustment for counterparty risk is the credit value adjustment. CVA is calculated as follows:

$$CVA = LGD \times \sum_{i=1}^{m} \times EE(t_i) \times PD(t_{i-1},\ t_i)$$

where:
LGD = loss given default or how much of the exposure one expects to lose in the event of a counterparty default; equal to 1 minus the recovery rate (1 – RR)
EE = discounted expected exposure for future dates
PD = marginal default probability

Speed and simplicity are the hallmarks of this calculation, which aggregates components from different departments of the risk management organization. The resulting amount may be expressed as a percentage of the notional value of the transaction on which it is based. Additionally, the formula assumes no wrong-way risk and does not require simulation default events, which simplifies the calculation.

Professor's Note: Remember that CVA is a cost to the counterparty that bears a greater propensity to default; therefore, the equation sometimes begins with a negative sign to represent CVA as a loss.

CVA Spread

To approximate the CVA as a spread, divide the CVA by the unit premium of a risky annuity [e.g., credit default swap (CDS)] for the contract in question, producing an annual spread in basis points. This would be a charge to the weaker counterparty. The left-hand side of the following calculation represents the CVA as a running spread:

$$\frac{CVA(t,T)}{CDS_{premium}(t,T)} = X^{CDS} \times EPE$$

where:
$CDS_{premium}(t, T)$ = unit premium value of a credit default swap
X^{CDS} = CDS premium at maturity date *T*; this amount can be thought of as a credit spread
EPE = expected positive exposure that is the average of the expected exposure over a preset time period, typically from the present to the maturity date of the transaction

Assumptions for this calculation include (1) EPE is constant over the entire profile, (2) default probability is constant over the entire profile, and (3) EE or default probability is symmetric over the entire profile.

Example: Computing CVA spread

A trader needs a quick approximation of the CVA spread on a swap. The exposure management group comes up with an EPE of 6%. The counterparty's credit spread is around 375 basis points (bps) per year. **Calculate** the CVA as a running spread.

Answer:

The CVA as a running spread would be computed as:

$$6\% \times 3.75\% = 23 \text{ bps}$$

This is the amount the trader may add to or subtract from the leg of the trade as the CVA or credit charge, and it is a common way to represent CVA as a risk charge to the client in a swap transaction.

Impact of Changes in Credit Spread and Recovery Rates

LO 30.4: Evaluate the impact of changes in the credit spread and recovery rate assumptions on CVA.

When evaluating the impact of the probability of default and recovery on CVA, the following factors must be considered: credit spread levels, the shape of the credit spread curve, the impact of the recovery rate, and the basis risk that arises between different recovery rate assumptions.

Regarding the impact of changes in the credit spread, the CVA will most often increase given an increase in the credit spread. However, the impact will not be linear because default probabilities are limited to 100%. If a counterparty is very close to default, the CVA will actually decrease slightly, and in default the CVA will fall to zero. When considering the shape of the credit spread curve, the CVA will be lower for an upward-sloping curve compared to a flat and a downward-sloping curve, and the CVA will be higher for a downward-sloping curve compared to a flat and an upward-sloping curve.

Regarding the impact of changes in recovery rate assumptions, increasing the recovery rate will increase the implied probability of default but reduce the resulting CVA. Differences in settled versus actual recovery rates may also be considered. The settled recovery is the recovery at default, while the actual recovery is the claim amount that will be received. As an example, consider a settled recovery rate of 10% and an actual recovery rate of 40%. In this situation, the higher actual recovery rate will produce a lower CVA compared to a 40% recovery assumption for both settled and actual recovery rates.

Incorporating Netting and Collateralization

LO 30.5: Explain how netting can be incorporated into the CVA calculation.

LO 30.7: Explain the impact of incorporating collateralization into the CVA calculation.

Netting reduces the CVA price as it nets (i.e., reduces) exposure when trades are settled. One must evaluate the change in CVA before and after a trade has been executed. The new trade should be sufficiently profitable to offset any increase in CVA at a minimum. This expression is shown as follows:

$$V(i) = \Delta CVA_{NS,i} = CVA(NS, i) - CVA(NS)$$

where:
V(i) = risk-free value of new trade *i*
CVA(NS, i) = CVA included in new trade in the netting set
CVA(NS) = CVA on all current trades within the netting set

Collateralization reduces the CVA, changing only the counterparty's expected exposure (EE), but not its default probability. Inclusion of minimum transfer and threshold amounts would correspondingly increase the CVA as they increase exposure linearly.

Incremental and Marginal CVA

LO 30.6: Define and calculate incremental CVA and marginal CVA, and explain how to convert CVA into a running spread.

The practicality of CVA lies in its ability to take into account risk mitigation provided by collateralization and netting. The usefulness of standalone CVA is limited to giving the risk manager a quick appraisal of the CVA charge.

Incremental CVA is the change (or increment) in CVA that a new trade will create, taking netting into account (i.e., the difference between CVA with and without the new trade). The formula differs from the original CVA only in the change in expected exposure. The ΔEE is the incremental change in EE at each point in time caused by the new trade, which impacts the original exposure.

Incremental CVA is important for pricing a new trade with respect to existing ones. CVA with netting will never be higher than CVA without netting because netting cannot increase exposure. The benefits of netting are a function of the transaction size. The larger the transaction, the smaller the benefit to the point where the value of incremental CVA will approach standalone CVA.

Marginal CVA enables the risk manager to break down netted trades into trade level contributions that sum to the total CVA. The calculation is identical to that for the standalone CVA, except for the substitution of marginal EE for initial EE. This metric

allows for more rigorous analysis, as it is useful for better understanding which trades have the greatest impact on a counterparty's CVA. It provides an ex-post view of the trades.

Converting CVA into a Running Spread

Converting an upfront CVA into a running spread CVA is also worth considering. Given an interest rate swap, the rate paid on the swap would need to change when charging a CVA to a client. This transformation would occur by dividing the CVA by the risky duration for the maturity under consideration. For example, assuming a five-year payer interest rate swap with a notional amount of 100M, a risky duration of 3.75, and a standalone CVA of 90,000, the additional spread would be calculated as:

$$90{,}000 \,/\, (3.75 \times 100{,}000{,}000) = 2.40 \text{ bps}$$

However, the addition of this spread will also impact the CVA. Therefore, the correct value should be computed in a recursive fashion until the risky MtM value declines to zero. This is accomplished by solving the following equation: $V_{C'} = CVA_{C'}$, where $V_{C'}$ is the contract value given the adjusted rate C'. This method ensures that the CVA is offset by the initial value and allows the adjusted rate (C') to become the hurdle rate for profitability.

Applying CVA to Exotic Products and Path Dependency

Applying CVA to exotic products and in the presence of path dependency presents special challenges.

Regarding **exotic products**, valuation may require techniques such as Monte Carlo simulation. Thus, value approximations to such products may be necessary to estimate their CVA values given the complexity in pricing the products themselves (e.g., swaptions may be treated as forward swaps, Bermudan option payoffs may be treated as European option payoffs).

Regarding **path dependency**, in order to assess future exposure at a given point in time, one must have information on the entire path from the present to that future date. As with exotic products, approximation of the probability calculation of path-dependent events will suffice when dealing with exotic derivative prices.

CVA for a Bilateral Contract

LO 30.8: Describe debt value adjustment (DVA) and bilateral CVA (BCVA).

LO 30.9: Calculate BCVA and BCVA spread.

Given a charge for counterparty risk that favors a stronger counterparty (typically a bank), CVA historically did not take into account that both counterparties could be subject to default risk. The 2007–2009 financial crisis changed risk parameters and perceptions drastically.

Counterparty risk is now viewed as *bilateral*. Bilateral counterparty risk assumes that both counterparties may default. The formula for the credit value adjustment for a bilateral contract derives from the original CVA formula and assumes no simultaneous default (e.g., wrong-way risk).

The positive expression in the following **bilateral credit value adjustment (BCVA)** formula represents the CVA of the counterparty, C, and the negative expression represents the CVA of the financial institution, I. The CVA of the institution is also known as the **debt value adjustment (DVA)**. The two terms in this expression are mirror images of one another. If the financial institution defaults first, it books a gain when the marked-to-market (MtM) exposure is negative. This is the case because the institution in default will only pay the counterparty the recovery amount of what they owe, which is a fraction of what they would have otherwise owed had they not defaulted. That difference is a gain to the defaulting party.

$$\text{BCVA} = \text{CVA} + \text{DVA}$$

$$\text{CVA} = +\text{LGD}_C \times \sum_{i=1}^{m} \text{EE}(t_i) \times \text{PD}_C(t_{i-1}, t_i)$$

$$\text{DVA} = -\text{LGD}_I \times \sum_{i=1}^{m} \text{NEE}(t_i) \times \text{PD}_I(t_{i-1}, t_i)$$

where:
NEE = negative expected exposure (EE from the counterparty's perspective)

Implications of the BCVA model include:

1. BCVA can be negative if the second expression is larger than the first, implying that the risk value of a derivative is greater than its risk-free value. Stand-alone CVA may only be positive.

2. Two counterparties in agreement on the parameters of the BCVA equation will settle up owing to the equation's symmetry. For example, Party 1 has BCVA of +X, then Party 2 has BCVA of –X. Party 2 owes Party 1 +X due to Party 2's counterparty risk.

3. Netting with BCVA may be a disadvantage when the second expression dominates, implying that the financial institution is riskier than its counterparty. Without netting, the institution may select contracts with a positive MtM settlement, discarding those with a negative MtM value as bankruptcy liabilities.

4. If both parties agree on the parameters of the BCVA calculation, then counterparty risk in the marketplace (the sum of all BCVAs) is zero. However, this holds more in theory than in practice.

Professor's Note: This BCVA formula excludes a survival probability, which considers the possibility that a financial institution may default before its counterparty. If this is the case, the institution will not suffer a loss from the counterparty. The survival probability will be included in the BCVA equation in Topic 33, when we discuss stress testing the debt value adjustment.

BCVA Spread

BCVA may be expressed as a spread or basis point charge to the weaker counterparty as follows:

$$\frac{\text{BCVA}(t,T)}{\text{CDS}_{\text{premium}}(t,T)} = X_C^{CDS} \times \text{EPE} - X_I^{CDS} \times \text{ENE}$$

where :
X_I^{CDS} = the institution's own CDS spread
ENE = expected negative exposure (the opposite of EPE)

Here the BCVA can be represented as a running spread. The formula implies that the institution may account for its own default through reduction of the unilateral CVA charge by its own credit spread multiplied by the ENE.

The calculation of this formula is identical to that for unilateral CVA. It differs only in that there is an additional identical subtractive calculation to reflect the BCVA of the financial institution.

Example: Computing BCVA

A risk manager needs a quick calculation of the BCVA on a swap. Assume inputs are as follows: EPE = 5%, ENE = 3%, counterparty credit spread = 300 bps, and financial institution credit spread = 200 bps. **Compute** BCVA from the perspective of the financial institution.

Answer:

From the perspective of the financial institution:

EPE × counterparty credit spread – ENE × institution credit spread

5% × 300 – 3% × 200 = 9 bps

This is what the financial institution may charge the counterparty for overall counterparty risk.

Key Concepts

LO 30.1

Motivations for pricing counterparty risk include (1) organization of responsibilities within the institution with respect to the pricing calculation and (2) determining whether a trade is sufficiently possible when factoring in counterparty risk charge.

LO 30.2

A credit value adjustment (CVA) is the price of counterparty risk. A positive value is a cost to the counterparty bearing the risk. The basic CVA formula assumes no wrong-way risk.

LO 30.3

CVA is calculated as follows:

$$\text{CVA} = \text{LGD} \times \sum_{i=1}^{m} \times \text{EE}(t_i) \times \text{PD}(t_{i-1}, t_i)$$

CVA as a spread is CVA divided by the risky annuity for the maturity of the contract in question, producing an annual spread or charge expressed in basis points:

$$\frac{\text{CVA}(t,T)}{\text{CDS}_{\text{premium}}(t,T)} = X^{\text{CDS}} \times \text{EPE}$$

LO 30.4

Credit spread levels, the shape of the credit spread curve, the impact of the recovery rate, and the basis risk that arises from different recovery rate assumptions must all be considered when evaluating the impact of the default probability and recovery on CVA.

LO 30.5

Netting reduces the CVA price because it nets exposure when trades are settled.

LO 30.6

Incremental CVA is used to calculate the cost of a new trade versus an existing one to determine the effect that the new trade has on CVA. Standalone CVA cannot do this. The formula for the incremental CVA calculation is identical to that for standalone CVA, except for the incremental expected exposure.

Marginal CVA is used for trade level attribution (i.e., to discover the determinants of the CVA). The formula for the calculation of marginal CVA is identical to that for standalone CVA, except for the substitution of marginal expected exposure for expected exposure.

LO 30.7

Collateralization reduces the CVA, changing only the counterparty's expected exposure.

LO 30.8

Bilateral CVA is a collateral value adjustment that takes into account the possibility that both counterparties could default, though not simultaneously. The CVA of the financial institution is also known as the debt value adjustment (DVA).The BCVA is the sum of CVA and DVA components.

$$\text{BCVA} = \text{CVA} + \text{DVA}$$

$$\text{CVA} = +\text{LGD}_C \times \sum_{i=1}^{m} \text{EE}(t_i) \times \text{PD}_C(t_{i-1}, t_i)$$

$$\text{DVA} = -\text{LGD}_I \times \sum_{i=1}^{m} \text{NEE}(t_i) \times \text{PD}_I(t_{i-1}, t_i)$$

Implications of the BCVA model include:

- BCVA can be negative. Stand-alone CVA may only be positive (representing a cost).
- Parties in agreement on the BCVA settle in accordance with the BCVA equation's symmetry.
- Netting may be disadvantageous where the financial institution's counterparty risk exceeds that of the counterparty. Without it, the institution can pick which contracts to settle.
- Parties in agreement will have in theory all BCVAs net out to zero due to the symmetrical nature of the BCVA formula.

LO 30.9

The BCVA formula as a credit spread is:

$$\frac{\text{BCVA}(t, T)}{\text{CDS}_{\text{premium}}(t, T)} = X_C^{\text{CDS}} \times \text{EPE} - X_I^{\text{CDS}} \times \text{ENE}$$

To price BCVA: (credit spread of counterparty A × EPE) – (credit spread of counterparty B × ENE) = either positive number that stronger counterparty charges the weaker one or negative number that the stronger counterparty may owe the weaker one if its ENE is greater than the counterparty's EPE.

Negative BCVA: The counterparty has a higher chance of defaulting and will owe money (CVA cost).

Positive BCVA: the counterparty has a lower chance of defaulting and will be owed money (recipient of CVA fee).

Concept Checkers

1. Which of the following statements is not a motivation for pricing counterparty risk?
   A. Accurate pricing should only account for the cost of the trade.
   B. Counterparty risk pricing should account for risk mitigants.
   C. Best practices organize pricing responsibilities in the organization.
   D. Pricing bilateral derivatives contracts.

2. With respect to the CVA calculation, which of the following statements is correct when a risk manager wishes to understand which trades have the greatest impact on a counterparty's CVA? The manager would use:
   A. incremental CVA because it accounts for the change in CVA once the new trade is priced, accounting for netting.
   B. marginal CVA because he could break down netted trades into trade level contributions.
   C. incremental CVA because he could break down netted trades into trade level contributions.
   D. marginal CVA because it accounts for the change in CVA once the new trade is priced, accounting for netting.

3. A trader wants to know the approximate CVA for a counterparty in a swap transaction. The counterparty's expected potential exposure (EPE) is 7%, and its credit spread is 475 basis points. What is the CVA as a running spread?
   A. 0.33%.
   B. 1.48%.
   C. 2.25%.
   D. 9.75%.

4. Regarding the impact of changes in the credit spread and recovery rate assumptions on the CVA, which of the following statements is true?
   A. A decrease in the credit spread will most often increase the CVA.
   B. For an upward-sloping curve, the CVA will be higher compared to a downward-sloping curve.
   C. Increasing the recovery rate will reduce the CVA.
   D. If the actual recovery rate is higher than the settled recovery rate, the CVA will most likely be higher compared to a situation where both recovery assumptions are the same for both rates.

5. When incorporating netting and collateralization into the CVA calculation, which of the following statements is incorrect?
   I. Netting increases the CVA price because it reduces exposure when trades are settled.
   II. Collateralization does not change the CVA because it only changes the counterparty's expected exposure.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

Concept Checker Answers

1. **A** Accurate pricing should account for not only the cost of the trade, but also the cost of counterparty risk.

2. **B** Understanding which trades have the greatest impact on a counterparty's credit value adjustment requires use of the marginal CVA. Incremental CVA, by contrast, is useful for pricing a new trade with respect to an existing one.

3. **A** Calculation of the CVA as a running spread entails multiplying the counterparty's EPE by its credit spread:

   $7\% \times 4.75\% = 33$ bps

4. **C** Increasing the recovery rate will increase the implied probability of default but reduce the resulting CVA. The CVA will most often increase given an increase in the credit spread. When considering the shape of the credit spread curve, the CVA will be lower for an upward-sloping curve compared to a downward-sloping curve. Finally, a higher actual recovery rate will most likely lead to a lower CVA compared to a situation where the recovery assumptions are the same for both actual and settled rates.

5. **C** Both statements are incorrect. Netting reduces the CVA price as it reduces exposure when trades are settled. Collateralization also reduces the CVA, changing only the counterparty's expected exposure (EE), but not its default probability.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Wrong-way Risk

Topic 31

Exam Focus

The most recent global financial crisis and European sovereign debt crisis illustrated the significance of wrong-way risk and right-way risk. For example, buyers of protection against bond defaults may witness an impressive gain in their position due to falling bond prices as a result of some macroeconomic events. However, at the same time, falling bond prices increase the risk exposure and default probability of a counterparty due to the adverse impact of macroeconomic events, resulting in an overall increase in counterparty risk. This is an example of wrong-way risk (WWR). Normal derivatives markets are characterized as possessing right-way risk (RWR), in which hedges produce successful expected results. Macroeconomic events affect risk exposure and default probability in a favorable manner such that the overall expected counterparty risk declines. For the exam, be able to explain both wrong-way risk and right-way risk as well as identify these risks in transactions such as put options, call options, credit default swaps, foreign currency transactions, interest rate and currency swaps, and commodities.

Wrong-Way Risk vs. Right-Way Risk

LO 31.1: Describe wrong-way risk and contrast it with right-way risk.

Wrong-way risk (WWR) is an outcome of any association, dependence, linkage, or interrelationship between exposure and counterparty creditworthiness that generates an overall increase in counterparty risk and, therefore, an increase in the amount of the credit value adjustment (CVA). WWR also results in a reduction of the debt value adjustment (DVA). WWR can be hard to determine due to difficulties assessing the relationship among variables and the lack of relevant historical data.

Right-way risk (RWR) is just the opposite of WWR. That is, any dependence, linkage, or interrelationship between the exposure and default probability of a counterparty producing an overall decrease in counterparty risk is described as RWR. RWR decreases the CVA and increases the DVA.

It is also worth mentioning that WWR has been the center of attention in historical context, while RWR has been paid relatively little attention. However, both risks are important, and financial institutions should strive to increase RWR and decrease WWR.

Another way to contrast WWR and RWR is to think that "normality" in derivatives markets is an example of RWR. That is, derivatives transactions produce intended results if the market is functioning in an expected manner. For instance, a coffee producer would sell (i.e., short) forward or futures contracts in order to protect against the downside risk of falling prices in the future, and a textile owner (that manufactures cotton cloth) would go

long in cotton derivatives contracts if she anticipates a rise in cotton prices. Thus, RWR produces a favorable relation between default probability and exposure, reducing overall counterparty risk. Hedges, in normal functioning markets, should automatically generate RWR because the fundamental purpose of hedges is to curtail counterparty risk.

Professor's Note: We are using derivatives markets just for illustration of wrong-way and right-way risks. By no means are these risks confined only to derivatives.

Markets and numerous interactions (e.g., market credit interaction) do not always produce normal behavior, as evidenced by the recent global financial crisis. Those who were seeking protection against the default of debt issuers (e.g., on collateralized debt obligations) became victims of WWR when unfavorable interaction between exposures and insurers' default probabilities (which were supposed to provide protection) intensified the amount of counterparty credit risk.

The amount of counterparty risk is roughly equal to the product of exposure and the counterparty's default probability at a specified loss rate given default. Counterparty risk is a kind of credit risk that is estimated as loss reserve for loans, and in over-the-counter (OTC) derivatives markets, it is similar to estimating loan reserves.

Loan exposure, however, is normally assumed to be a fixed amount for a specified time period, whereas in OTC derivatives, the exposure fluctuates depending on market conditions. An example of WWR (RWR) would be a change in exposure and counterparty credit quality, producing an unfavorable (favorable) dependence in exposure and counterparty credit quality and resulting in an increase (decrease) in the amount of overall counterparty risk. The change in exposure and credit quality could be due to numerous external factors such as interest rates, inflation, exchange rate movements, and global events. Note that credit quality increases actually increase WWR. This is because counterparties with high credit quality are less likely to default. As a result, the occurrence of a default by a counterparty with high credit quality is less expected than a default by a counterparty with low credit quality.

Examples of Wrong-Way Risk and Right-Way Risk

LO 31.2: Identify examples of wrong-way risk and examples of right-way risk.

For this LO, we'll create a few hypothetical examples of WWR and RWR. For example, what if Company XYZ (the borrower) and the guarantor on XYZ's loan, Company ABC, share ownership in a business (or are in the same industry)? Due to some market or economic factors, both may default together (WWR), whereas if the guarantor and the borrower are not in the same industry (nor have shared ownership), XYZ's loan guarantee may still be valid, even if XYZ defaults (RWR).

What if ABC has sold protection much higher than its capital in a concentrated area (business or industry) and XYZ has bought protection (insurance) from ABC? Macro factors may increase the "exposure" for the guarantor (ABC), and due to positive interaction between exposure and credit quality, the overall counterparty (guarantor) risk increases to

the extent that XYZ's protection becomes meaningless (WWR). In contrast, the reverse of the situation may generate a favorable state—an increase in exposure may be sufficiently offset by an increase in creditworthiness.

The CVA, which is based on the amount of counterparty risk, is generally approximated by the product of exposure and the default probability of the counterparty (for a given recovery rate). This estimation is based on an underlying assumption that these events are independent. However, they may not be independent (as evidenced in the recent financial crisis). Unfavorable (favorable) association between default probability (credit risk) and exposure (market risk) may produce WWR (RWR), increasing (decreasing) the overall CVA.

Quantifying WWR and RWR involves estimation of the CVA based on expected exposure, conditional on counterparty default (under the more realistic scenario of the presence of interconnected markets with systemic risk), whereas under the independence assumption, we use unconditional default probability.

It is estimated that conditional expected exposure will increase if the exposure (e.g., value of a forward contract) and the default probability of the counterparty are positively correlated, exhibiting WWR. On the other hand, negative correlation in this instance will lower the conditional expected exposure, showing RWR.

As discussed earlier, the overall counterparty risk stems from a situation in which the counterparty credit quality is linked with macro (and global) factors that also impact the exposure of transactions. The transaction can be any of the following: put options, call options, foreign currency transactions, forward contracts, credit default swaps, or interest rate and currency swaps. Let us examine WWR and RWR as they relate to some of these transactions.

Over-the-Counter Put Option

A put option gives the right to the long (buyer) to sell an underlying instrument at a predetermined price whereas the short (counterparty) is obligated to buy if the option is exercised. Out-of-the money put options have more WWR than in-the-money put options.

Macroeconomic events (such as interest rates, inflation, industry- and sector-specific factors, or global factors) may deteriorate the creditworthiness of the counterparty, increasing the default probability. The same factors may trigger a fall in the underlying (e.g., stock) asset's price, generating positive payoffs for the long but increasing the counterparty risk exposure. Before the long gets too excited to see an increase in payoffs, he is hit by the realization of increasingly becoming a victim of WWR, due to positive correlation between the risk exposure of the counterparty and probability of default of the counterparty producing an overall increase in counterparty risk. The payoffs may not materialize, although they are increasing. On the other hand, normalcy of the transaction would be termed as RWR if the counterparty is able to fulfill its obligation despite an increase in its position obligation.

Professor's Note: We are assuming in the previous put option example that the counterparty and the underlying issuer are the same in order to clearly illustrate WWR. The positive association between default probability and exposure will still give rise to WWR if the counterparty and underlying issuer are not the same.

Over-the-Counter Call Option

A call option gives the right to the long (buyer) to buy an underlying instrument at a predetermined price whereas the short (counterparty) is obligated to sell at the agreed-upon price if the option is exercised. Like the put option, we are assuming the counterparty and the underlying issuer are the same.

Assume that due to changes in some macroeconomic and global factors, the default probability of the counterparty declines, and the price of the underlying asset (e.g., stock) increases, producing higher payoffs for the call buyer. In this instance, his excitement of making money will be appropriate because the counterparty will be in a strong position to pay off its obligation (due to the overall increase in creditworthiness). Such an outcome will be considered the "normalcy" of the transaction, and it is termed RWR. The short is able to fulfill its obligation despite the increase in its position obligation. On the other hand, if the counterparty is unable to fulfill its obligation due to the increase in its position obligation (higher value of underlying for the long, but higher obligation for the short—an increase in counterparty risk exposure), it would be an example of WWR (from the standpoint of the long position).

Credit Default Swaps (CDSs)

The 2007–2009 credit crisis offers a classic example of WWR from the perspective of the longs (i.e., the buyers) who had bought protection on issuers default on collateralized debt obligations (CDOs) or bonds backed by mortgage-backed securities (MBSs) via credit default swaps (CDSs).

As the real estate bubble burst and the market started taking a downward freefall, the value of MBSs started exhibiting a freefall as well. The monoline insurers, such as AMBAC and MBIA, had taken highly concentrated positions in offering protection against MBSs and CDOs. As the issuers of MBSs and CDOs started defaulting, the insurers were flooded by claims from the ones who had bought the protection (i.e., holders of CDSs).

The value of CDSs was rising, but this gain was generating an increase in risk exposure to the counterparty. Both the probability of default and the risk exposure of the insurers were rising. The unfortunate buyers of protection soon found out that the macrocredit and exposure linkage had produced unfavorable results for them. Despite huge gains on their positions, nothing materialized due to the deteriorating creditworthiness of the issuers, an example of WWR.

The normalcy of the transaction would be if the counterparty could fulfill its obligation despite an increase in position exposure (perhaps due to a negative association between risk exposure and probability of default). This would be an example of RWR. If insurance

company ABC, for example, had taken a nonconcentrated exposure, it might not have experienced a decline in its creditworthiness (due to fewer claims) and would have been able to satisfy its obligations despite increasing risk exposure in the CDSs.

Foreign Currency Transactions

Consider a commercial bank in a developed economy (e.g., the United States) that enters into a cross currency agreement with a commercial bank (counterparty) in an emerging market (e.g., Uzbekistan), under which the counterparty will deliver developed market currency in return for local currency.

Macro conditions in the emerging country, such as a sovereign debt crisis, generate credit stress for the local bank, as well as a decline (depreciation) of local currency. The value of the transaction increases substantially for the financial institution in the developed economy due to the declining currency of the emerging economy. At the same time, the counterparty risk exposure increases as the gain for the financial institution in the developed economy increases.

Increases in default probability (due to credit stress) and risk exposure (due to declining currency) increase counterparty risk, resulting in WWR for the financial institution in the developed economy.

If the counterparty risk exposure and the credit quality are not unfavorably associated, then the risk exposure may increase, but the probability of default may decline (due to improvement in creditworthiness), producing a reduction in overall counterparty risk. This would be an example of RWR.

Foreign Currency Swaps

A real-world example will further clarify WWR in the foreign currency swaps market. Prior to the recent credit crisis in the United States, numerous financial institutions in Japan had entered into swap agreements with U.S. financial institutions to obtain dollar funding by using yen. They pledged yen to get U.S. dollars. After the default of Lehman Brothers, the financial crisis reached its peak, raising grave concerns about the economic slowdown of the U.S. and European economies. The yen significantly appreciated against the U.S. dollar, resulting in a substantial gain to Japanese bank positions (the pledged yen will buy more dollars, and U.S. banks will have to surrender more dollars for the pledged yen), increasing the counterparty risk exposure for Japanese banks. At the same time, deteriorating macro conditions had a negative impact on U.S. banks and the economy. In addition, the default probabilities of the U.S. financial institutions increased. Positive (unfavorable) association between counterparty risk exposure and default probability generated an overall increase in counterparty risk for Japanese banks, and they experienced WWR.

If the risk exposure and default probabilities are not positively associated, the normalcy of the transaction would balance out the increase in risk exposure by improving the creditworthiness of the financial institutions (macro factors may be related to both events in a different manner), lowering overall counterparty risk. The counterparty is able to meet its obligation despite an increase in risk exposure (due to an appreciating yen). This would be an example of RWR.

Interest Rate Transactions

Interest rate swaps provide another good illustration of WWR. In an interest rate swap, one party (i.e., the long or fixed-rate receiver) enters into an agreement with a counterparty (i.e., the fixed-rate payer) to receive a fixed rate and pay a floating rate. The fixed-rate receiver gains if the market interest rate (the swap rate) falls.

Assume due to macroeconomic conditions (e.g., an economic downturn), policy interest rates are lowered. The fixed-rate receiver experiences a value gain to the extent that the swap rate declines against the counterparty with the fixed-rate payer and floating-rate receiver. However, this gain for the fixed-rate receiver also produces an increase in its counterparty risk exposure. Furthermore, if the economic downturn would also increase the default probability, then overall counterparty risk will increase, generating WWR for the fixed-rate receiver.

This is exactly what happened during the recent European sovereign debt crisis. Due to lower inflation and an economic recession, the policy interest rates were lowered. The euro (interest rate) swap rate declined, producing a gain for those who were holding fixed interest rate receiver positions against Italian financial institutions (fixed-rate payer). However, the decline in the euro swap rate also increased the counterparty risk exposure. Deteriorating economic conditions also increased the default probability of Italian financial institutions. An increase in both the risk exposure and default probability resulted in an overall increase in counterparty risk, generating WWR for the holder of fixed-rate receiver swaps.

In the absence of a positive association between risk exposure and default probability, the Italian financial institutions might have been able to fulfill their obligations comfortably, despite the increase in exposure, generating RWR.

Commodities

Airlines hedge against the risk of rising oil prices. For example, assume an airline is long an oil forward contract at a fixed price. The counterparty is a dealer who has taken heavy concentrated positions. If oil prices rise, the gains for the airline will rise. The airline will buy cheap oil because the spot price will be higher than the locked-in forward price, but at the same time, the risk exposure for the dealer will increase. Because the dealer had concentrated positions, there may be a flood of claims (several forward contract claims brought by various airlines), putting intense pressure on the credit quality of the counterparty. Thus, an increase in both the risk exposure and the default probability will increase overall counterparty risk, producing WWR.

On the other hand, a dealer with a nonconcentrated position may continue to have sound creditworthiness despite rising exposure. Thus, the dealer will be able to fulfill her obligation, lowering the overall expected amount of risk exposure from the standpoint of the airline. This would be an example of RWR.

The Impact of WWR on Collateral and CCPs

LO 31.3: Discuss the impact of wrong-way risk on collateral and central counterparties.

Collateral can be viewed as a way to reduce exposure. Therefore, when exposure is increasing significantly, it's important to evaluate the overall impact of collateral on WWR. In cases where exposure is gradually increasing (before default), collateral is typically taken to minimize the impact of WWR. In this scenario, the benefit from collateral will increase as WWR increases, because additional collateral is relatively easy to request and receive. However, in cases where exposure jumps at a certain point in time, the benefits of collateral will be very limited. For example, with a jump in exposure, such as a currency devaluation associated with a sovereign default, it is much more difficult to receive collateral in a timely fashion.

Central counterparties (CCPs) are particularly susceptible to WWR given their dependence on collateral and default fund contributions. Recall from Topic 28 that the CCP relies on a defaulting member's posted margin (i.e., collateral) and default fund contribution to absorb potential losses. If these amounts do not cover losses, the CCP will need to use their own equity capital and/or default funds from non-defaulting members to help remain solvent.

However, the CCP's loss waterfall structure may be insufficient if member initial margins and default fund contributions fail to incorporate WWR. Since WWR tends to increase with increasing levels of credit quality, it could be argued that CCPs should demand higher levels of margin and default fund contributions from those members with higher credit quality. In addition, the collateral accepted by the CCP may also carry WWR. Some members may choose to post risky and illiquid assets as collateral, which may create higher levels of WWR for the CCP. One way to mitigate this practice is for the CCP to impose higher haircuts on specific assets that are accepted as collateral.

Key Concepts

LO 31.1

Financial institutions should pay more attention to wrong-way risk and right-way risk for planning purposes. The recent global financial crisis and European sovereign debt crisis have illustrated the significance of these risks.

Numerous macroeconomic events can impact exposure risk and default probability, producing an overall increase in counterparty credit risk. Position gains may not materialize due to an increase in the counterparty's overall risk. This is an example of wrong-way risk.

On the other hand, favorable associations between exposure risk and default probability resulting from changes in macro factors may produce a decline in overall counterparty credit risk. This is an example of right-way risk.

LO 31.2

Wrong-way risk and right-way risk can be identified in numerous investment products and transactions, such as call options, put options, credit default swaps, foreign currency transactions, interest rate products, currency swaps, and forward contracts.

The key to identify wrong-way and right-way risk is to assess the impact on overall counterparty risk. If the co-movement between risk exposure and default probability generates an overall increase (decrease) in counterparty risk, it would be an example of wrong-way risk (right-way risk).

During the recent global financial crisis, credit default swaps offered a classic example of wrong-way risk. The buyers of credit default swaps (protection against the default of bond issuers) experienced a substantial gain as the values of the bonds backed by mortgage-backed securities started tumbling. However, the collapse of the mortgage market not only increased the risk exposure but also the default probability, leading to an overall increase in counterparty risk. There were many buyers of credit default swaps whose gains remained paper gains due to the deteriorating creditworthiness of the counterparty.

LO 31.3

When exposure is increasing gradually, the impact of collateral on WWR will be beneficial. As WWR increases, more collateral can be taken. However, when there is a jump in exposure, the impact of collateral on WWR will be limited due to the inability to receive collateral in a timely fashion.

Central counterparties (CCPs) may be impacted by WWR if they fail to incorporate this risk into their member's initial margins and default fund contributions. To mitigate the impact of WWR, CCPs should require higher margin (i.e., collateral) and default funds from members with better credit quality. CCPs should also impose higher haircuts on any posted collateral that may increase WWR.

Concept Checkers

1. How many of the following statements regarding wrong-way risk (WWR) and right-way risk (RWR) are correct?
   I. Co-movement in risk exposure and default probability producing a decline in overall risk is an example of wrong-way risk.
   II. Co-movement in risk exposure and default probability producing an increase in overall counterparty risk is an example of right-way risk.
   III. Co-movement in risk exposure and default probability producing neither a decline nor an increase in the overall counterparty risk is an example of wrong-way risk.
   IV. Co-movement in risk exposure and default probability producing a decline in risk exposure but an increase in counterparty default probability is an example of right-way risk.
   A. None.
   B. All.
   C. Two.
   D. Three.

2. Which of the following events would likely lead to an increase in WWR?
   I. The borrower and the guarantor are business partners.
   II. A monoline insurer sold protection concentrated in a business or industry.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

3. Which of the following statements regarding WWR and RWR is correct?
   A. A long put option is subject to WWR if both risk exposure and counterparty default probability decrease.
   B. A long call option experiences RWR if the interaction between risk exposure and counterparty default probability produces an overall decline in counterparty risk.
   C. Declining local currency can decrease the position gain in a foreign currency transaction, while increasing risk exposure of the counterparty.
   D. The 2007–2009 credit crisis provides an example of WWR from the perspective of a long who had sold credit default swaps (CDSs) as protection against bond issuers' default.

4. How many of the following statements regarding counterparty risk are correct?
   I. Speculation in normal-functioning derivatives markets automatically produces RWR.
   II. RWR has been the center of attention in historical context, whereas WWR has not been paid much relative attention.
   III. The counterparty default probability does not enter into the equation for estimating the overall counterparty risk.
   IV. Unlike exposure to OTC derivatives, which is normally assumed to be a fixed amount for a specified time period, exposure to bank loans fluctuates depending on market conditions.
   A. None.
   B. All.
   C. Two.
   D. Three.

5. Which of the following statements is correct?
   I. Depreciation of the yen after the default of Lehman Brothers gave a substantial gain to Japanese bank foreign currency swaps positions to obtain dollar funding in interest rate swaps.
   II. Fixed-rate receivers experience a value gain to the extent that the swap rate increases.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

Concept Checker Answers

1. **A** A decline in overall counterparty risk is an example of right-way risk. An increase in overall counterparty risk is an example of wrong-way risk. An increase in overall counterparty risk is a condition for the emergence of wrong-way risk. A decline in risk exposure but increase in counterparty default probability may or may not lower overall counterparty risk.

2. **C** WWR will increase if the borrower and guarantor are business partners. The guarantees offered by a monoline insurer may turn out to be worthless if the risk exposure increases and the guarantor is hit by a flood of claims due to a concentrated position in an industry or business.

3. **B** A long call option experiences RWR if risk exposure and counterparty default probability results in decreased counterparty risk. A long put option is subject to WWR if both risk exposure and counterparty default probability *increase*. Declining local currency can *increase* the position gain in a foreign currency transaction, while increasing counterparty risk exposure. The 2007–2009 credit crisis provides an example of WWR from the perspective of a long who had *bought* CDSs as protection against bond issuers' default.

4. **A** Hedging, and not speculation, in normal functioning markets automatically produces RWR. Historically, RWR was relatively neglected by institutions for planning purposes. The counterparty default probability is one of the key elements in estimating overall counterparty risk. OTC exposures fluctuate based on market conditions.

5. **D** Appreciation, and not depreciation, of the yen generated a substantial gain for Japanese banks with foreign currency swaps positions. A fixed-rate receiver experiences a value gain to the extent that the swap rate declines.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

The Evolution of Stress Testing Counterparty Exposures

Topic 32

Exam Focus

In this topic, we take a detailed look at counterparty credit risk measurement and management. We begin by differentiating between the various measures of exposure. Next, we look at the treatment of counterparty credit risk, both as a credit risk and as a market risk. We then review the credit valuation adjustment (CVA) and stresses to the CVA. For the exam, be able to describe a stress test that can be performed on both a loan portfolio and a derivatives portfolio. In addition, ensure that you are able to calculate the stressed expected loss. Finally, be able to calculate stressed CVA and understand how the debt value adjustment (DVA) differs from the CVA.

Counterparty Credit Risk Exposure Measures

LO 32.1: Differentiate among current exposure, peak exposure, expected exposure, and expected positive exposure.

The concept of **counterparty credit risk** (CCR) and its measurement and management gained prominence in the 1990s, and it now forms a critical part of most organizations' risk governance. Financial institutions incorporated CCR through analyzing their derivatives exposures and by tracking the current exposure to their counterparties. Institutions measured regulatory capital for CCR as add-ons to current exposures, calculated as a percentage of gross notional derivatives values.

With the rise in importance of measuring CCR, modeling CCR also evolved. Initially, potential exposure models were used to measure and limit CCR. This approach evolved into expected positive exposure models, which allowed derivatives to be incorporated into portfolio risk models along with loans. The measurement of CCR also formed the basis for regulatory capital under Basel II and allowed for the incorporation of credit mitigants into risk modeling, including netting agreements.

There are four important definitions of exposure measures:

- **Current exposure**. Also called replacement cost, current exposure is the greater of (1) zero or (2) the market value of a transaction (or a portfolio of transactions) that would be lost if the counterparty defaulted and no value was recovered during bankruptcy.
- **Peak exposure**. Peak exposure measures the distribution of exposures at a high percentile (95% or 99%) at a given future date prior to the maturity of the longest maturity exposure in the netting group. Peak exposure is usually generated for many future dates.

- **Expected exposure.** Expected exposure measures the mean (average) distribution of exposures at a given future date prior to the maturity of the longest maturity exposure in the netting group. Expected exposure is also typically generated for many future dates.
- **Expected positive exposure (EPE).** EPE is the weighted average of expected exposures over time. The weights represent the proportion of individual expected exposures of the entire time interval. For the purposes of calculating the minimum capital requirement, the average is measured over the first year or over the length of the longest maturing contract.

One of the issues with CCR is **wrong-way risk**. Wrong-way risk is the risk that the exposure from a counterparty grows at the same time that the risk of default by the counterparty increases. Note that wrong-way risk does not arise with fixed-rate loans.

CCR Treatment

LO 32.2: Explain the treatment of counterparty credit risk (CCR) both as a credit risk and as a market risk and describe its implications for trading activities and risk management for a financial institution.

The treatment of CCR as a market risk was historically done through pricing in a **credit valuation adjustment** (CVA). CVA represents the market value of the CCR. Before the 2007–2009 financial crisis, institutions saw stable credit spreads and CVAs that made up only a small component of a derivatives portfolio. When the financial crisis resulted in unusual losses and gains, institutions began to pay closer attention to risk managing the CVA.

Financial institutions may view CCR as either a credit risk or a market risk and may manage the credit portfolio accordingly, but looking at it as only one type of risk (in a silo) exposes the institution to the risk from the other side.

Treating CCR as a credit risk exposes the institution to changes in CVA; therefore, CVA must be included when valuing a derivatives portfolio. Not including the CVA could lead to large swings in market value. Credit risk is managed at inception or typically through collateral arrangements, but it is not actively managed once the trades are set up. Since at default all trades need to be replaced in the market, emphasis is on risk mitigation and credit evaluation.

Treating CCR as a market risk allows an institution to hedge market risk losses but leaves it exposed to declines in counterparty creditworthiness and default. However, CCR can be hedged through replacing contracts with a counterparty instead of waiting for default to occur. This can be achieved by buying positions in proportion to the counterparty's probability of default (PD). A counterparty with a low PD will only have a small component of its trades replaced this way, while counterparties with deteriorating credit quality will see their trades replaced faster and moved to other counterparties.

The treatment of CCR as both a credit risk and a market risk creates a large variety of measurements that can be complex to interpret. For example, credit risk uses current exposure, peak exposure, and expected exposure, while market risk uses CVA and variability in CVA (measured by VaR of CVA). When stress testing the portfolio, the number of stress

results can be very large. By classifying CCR as both a credit risk and a market risk, the number of stress results would equal at least twice the number of counterparties plus one (stresses are run for each counterparty as well as the aggregate portfolio), and would be at least double that amount again if instantaneous shocks were considered in addition to stressed risk measures.

Stress Testing Current Exposure

LO 32.3: Describe a stress test that can be performed on a loan portfolio and on a derivative portfolio.

Stress testing current exposure is the most common stress test. Financial institutions apply current exposure stresses to each counterparty by repricing portfolios under a scenario of risk-factor changes. Counterparties with the largest current exposures and largest stressed current exposures are typically reported to senior management.

For example, an institution that is stress testing current exposure using an equity crash involving a 25% decline in equity markets may create a table of the top counterparties with the largest stressed current exposure and include their credit ratings, mark-to-market values, collateral values, and current exposures. In effect, the table would indicate to management which counterparties are most vulnerable to a large scale equity market decline and how much the counterparties would owe the financial institution. Of course, financial institutions could construct tables for other stresses as well, including credit events and interest-rate shocks. The different stress scenarios would likely include different counterparties.

However, stress tests of current exposure suffer from two main shortcomings: (1) aggregating results is challenging and (2) it does not provide information on wrong-way risk.

Aggregating stress results needs to incorporate additional information for it to be meaningful. Simply taking the sum of all exposures only looks at a loss that would occur if all counterparties were to simultaneously default, which is an unlikely scenario. In addition, the stressed current exposures do not factor in the credit quality of the counterparty. The stress results, therefore, only look at the trade values and not the counterparty's capacity or willingness to repay its obligations. This difference becomes especially relevant when comparing the exposures between high-risk early stage companies and highly rated mature companies. Nevertheless, the task of incorporating counterparty credit quality into each stress scenario is onerous.

The stress results of current exposure also do not provide information on wrong-way risk. Since the stress measures already omit the credit quality of the counterparty, they cannot provide meaningful information on the correlation of exposure with credit quality.

Stress Testing Expected Loss

LO 32.4: Calculate the stressed expected loss, the stress loss for the loan portfolio and the stress loss on a derivative portfolio.

Loan Portfolios

The **expected loss** (EL) for any counterparty in a loan portfolio is a function of the probability of default (PD_i), exposure at default (EAD_i), and loss given default (LGD_i). The EL for a portfolio is the sum of the individual exposures:

$$EL = \sum_{i=1}^{N} PD_i \times EAD_i \times LGD_i$$

Stress testing the EL could involve stressing the PD, which is a function of several other variables, including the unemployment rate or a relevant exchange rate. The **stressed expected loss** (EL_S) is, therefore, conditional on the impact of these variables on the PD. The EL_S can be expressed as:

$$EL_S = \sum_{i=1}^{N} PD_i^S \times EAD_i \times LGD_i$$

The *stress loss* for the loan portfolio is the difference between EL_S and EL. The financial institution could create different stress scenarios by increasing the PDs or by stressing the various variables. Note that the variables tend to be macroeconomic or balance sheet values.

Derivatives Portfolios

The EL and EL_S for a derivatives portfolio are derived similarly to the loan portfolio in that they both use the PD and LGD. However, exposure at default, which is stochastic and depends on market factors, is replaced with the expected positive exposure (EPE_i) multiplied by an alpha factor (α). This allows CCR exposures to be used in a portfolio credit model. We can then measure EL and EL_S for derivatives portfolios as:

$$EL = \sum_{i=1}^{N} PD_i \times (EPE_i \times \alpha) \times LGD_i$$

$$EL_S = \sum_{i=1}^{N} PD_i^S \times \left(EPE_i^S \times \alpha\right) \times LGD_i$$

Stress losses are done on a portfolio of derivatives counterparties. Similar to the loan portfolio, the financial institution could create different stress scenarios by increasing the PDs, or by stressing macroeconomic variables, balance sheet values, or values of financial instruments.

In the context of EPE, institutions could also stress market variables including swap rates and equity prices. The stresses to these variables may either increase or decrease EL. Their overall impact will depend in part on the directional bias of the financial institution's portfolio, which counterparties are margined, and which have excess margin. This differs from stresses on the loan portfolio, which tend to be directionally the same and, therefore, have similar effects across counterparties. It is important to note that an institution that conducts EPE stresses does not need to separately consider aggregating them with its loan portfolio, since loans are not sensitive to market variables and will not change exposures due to changes in these variables.

Financial institutions typically shock a series of market variables instantaneously. During these instantaneous shocks, the institution shocks the initial value of a derivative prior to running the EPE simulation. How much this affects EPE will depend in part on the degree of collateralization and the portfolio's moneyness. A series of shocks could also be performed over time; however, the common approach is to perform shocks to current exposure only.

Financial institutions could also consider joint stresses between credit quality and market variables. Although this is conceptually easy, it is challenging in practice since the variables are not tied by any meaningful connection. Equity-based approaches may be the closest to modeling joint stresses; however, the link between a shock to exposure and the equity-based default probability is unclear. It is also difficult to model the connection between exposure and PD in calculating wrong-way risk. Currently, the best way to identify wrong-way risk is to stress current exposure and identify the counterparties most exposed to wrong-way risk.

Treating CCR as a credit risk allows an institution to improve the management of its loan portfolio. Performing stress tests to CCR allows aggregating losses with loan portfolios and allows considering counterparty credit quality. On the other hand, treating CCR as a market risk allows for easier joint stresses of credit quality and exposure, and allows an institution to derive the PD from market variables.

Stress Testing Credit Valuation Adjustment

LO 32.5: Describe a stress test that can be performed on CVA.

LO 32.6: Calculate the stressed CVA and the stress loss on CVA.

Stress testing CCR for market risk events looks at the losses in market value of a counterparty exposure due to market risk events or credit spread changes. Financial institutions typically only consider the **unilateral CVA** for stress testing, which looks at a counterparty's default to the institution under various market events. However, financial institutions should also consider the possibility that they could default to their counterparties, and, as a result, should consider their **bilateral CVA** (BCVA), which is discussed in LO 32.7.

To calculate the stressed CVA and the stress loss, let's first look at the formula for calculating CVA. The following is a simplified formula for CVA that does not factor in wrong-way risk:

$$\text{CVA}_n = \text{LGD}_n^* \times \sum_{j=1}^{T} \text{EE}_n^*(t_j) \times \text{PD}_n^*(t_{j-1}, t_j)$$

where:

LGD_n^* = risk-neutral loss given default

$\text{EE}_n^*(t_j)$ = risk-neutral discounted expected exposure

$\text{PD}_n^*(t_{j-1}, t_j)$ = risk-neutral marginal default probability

When aggregating across *N* counterparties in a portfolio, the formula for CVA becomes:

$$\text{CVA} = \sum_{n=1}^{N} \text{LGD}_n^* \times \sum_{j=1}^{T} \text{EE}_n^*(t_j) \times \text{PD}_n^*(t_{j-1}, t_j)$$

The components of this formula all depend on market variables, including credit spreads, market spreads, and derivatives values. Calculating a stressed CVA involves applying an instantaneous shock to these market variables, which could affect the discounted expected exposure or the risk-neutral marginal default probability. The **stressed CVA** can then be calculated as:

$$\text{CVA}_S = \sum_{n=1}^{N} \text{LGD}_n^* \times \sum_{j=1}^{T} \text{EE}_n^S(t_j) \times \text{PD}_n^S(t_{j-1}, t_j)$$

The *stress loss* is simply the difference between CVA_S and CVA.

Stress testing CCR in a credit-risk framework has similarities with stress testing in a market-risk framework. Both rely on EL as a function of LGD, exposure, and PD. Nevertheless, their values will differ depending on whether the view is from a market-risk or credit-risk perspective. The two primary differences include the use of risk-neutral values for CVA (versus physical values for ELs), and the use of ELs over the transaction's life for CVA (versus a specific time horizon for ELs).

In addition, CVA uses a market-based model for calculating the PD. The market-based approach has the advantage of being able to incorporate a correlation between the exposure and the PD. This correlation can significantly influence the CVA. Because there is uncertainty regarding the correlation, financial institutions should run stress tests to determine the effects on profit and loss from incorrect correlation assumptions.

Stress Testing Debt Value Adjustment

LO 32.7: Calculate the DVA and explain how stressing DVA enters into aggregating stress tests of CCR.

Financial institutions should include the liability effects in their stress calculations to properly calculate the CVA profit and loss. As a result, institutions could adequately incorporate the value of their option to default to a counterparty through the bilateral CVA. This component is often called the **debt value adjustment** (DVA).

The BCVA formula is similar to the CVA formula with two differences. First, BCVA incorporates **negative expected exposure** (NEE), which is calculated from the counterparty's perspective. Second, the option that the financial institution can default on its counterparty is dependent on the counterparty surviving first; therefore, the probability of the counterparty's survival must be included in the BCVA formula (we denote this as S_I, with *I* representing the financial institution). This change must also be reflected in the CVA formula. The BCVA formula can therefore be set up as:

$$\begin{aligned}\text{BCVA} = &+\sum_{n=1}^{N}\text{LGD}_n^* \times \sum_{j=1}^{T}\text{EE}_n^*(t_j)\times \text{PD}_n^*(t_{j-1},t_j)\times S_I^*(t_{j-1})\\ &-\sum_{n=1}^{N}\text{LGD}_I^* \times \sum_{j=1}^{T}\text{NEE}_n^*(t_j)\times \text{PD}_I^*(t_{j-1},t_j)\times S_n^*(t_{j-1})\end{aligned}$$

The probability of survival depends on credit default swap (CDS) spreads, and the losses depend on the financial institution's own credit spread. Institutions should be aware that this may result in counterintuitive results, for example, implying that losses occur because the institution's credit quality has improved. In any case, the financial institution should consider stress results for the BCVA and calculate stress losses by subtracting the current BCVA from the stressed BCVA.

The benefit of incorporating BCVA is that it allows CCR to be treated as market risk, which enables CCR to be included in market risk stress testing consistently. Any gains or losses from the BCVA stress could then be added to the institution's stress tests from market risk.

Shortcomings of Stress Testing CCR

LO 32.8: Describe the common pitfalls in stress testing CCR.

Stress testing CCR includes the following pitfalls:

- Stress testing CCR is a relatively new method, and institutions typically do not aggregate CCR with loan portfolio or trading position stress tests.
- Institutions typically stress test *current exposure* when incorporating the losses with loan or trading position. This is a mistake, because institutions should instead use *expected exposure* or *positive expected exposure*.
- Using current exposure can lead to significant errors, which is particularly evident in at-the-money exposures when measuring derivatives market values.
- When calculating changes in exposures, using delta sensitivities is also challenging for CCR since delta is nonlinear. The linearization of delta sensitivities in models can lead to significant errors.

Key Concepts

LO 32.1

The four definitions of counterparty credit risk (CCR) exposure measures are:

- Current exposure, or replacement cost, is the greater of zero or the market value of a transaction (or transactions) upon counterparty default, assuming no recovery in value.
- Peak exposure measures the distribution of exposures at a high percentile (95% or 99%) at a given future date before the maturity of the longest maturity exposure in the netting group.
- Expected exposure measures the mean distribution of exposures at a given future date prior to the maturity of the longest maturity exposure in the netting group.
- Expected positive exposure (EPE) is the weighted average of expected exposures over time, where the weights represent the proportion of individual expected exposures of the entire time interval.

LO 32.2

Credit valuation adjustment (CVA) represents the market value of the CCR. Financial institutions could view CCR as either credit risk or market risk, although it should consider both risks.

Treating CCR as credit risk exposes an institution to changes in CVA. CVA should, therefore, be included in valuing a derivatives portfolio, otherwise the portfolio could experience large changes in market value.

Treating CCR as market risk allows an institution to hedge market risk losses; however, it leaves the institution exposed to declines in counterparty creditworthiness and default.

Treating CCR as both credit risk and market risk is prudent, but this approach is complex and difficult to interpret.

LO 32.3

The most common stress test is stress testing current exposure. Stresses may include equity crash simulations, other credit events, or interest-rate shocks. Counterparties with the largest current exposures are generally reported to senior management.

Stress tests of current exposure have two primary shortcomings. First, aggregating results is challenging and stresses do not factor in the credit quality of the counterparty. Second, they do not provide information on wrong-way risk.

LO 32.4

In a loan portfolio, the expected loss (EL) for any one counterparty is a function of the probability of default (PD_i), exposure at default (EAD_i), and loss given default (LGD_i). The EL for a portfolio is the sum of the individual exposures.

The stressed expected loss (EL_S) is determined by stressing the PD. The stress loss for the loan portfolio is, therefore, the difference between the stressed EL and EL.

In a derivatives portfolio, the EL for any counterparty is a function of PD_i, LGD_i, and expected positive exposure (EPE_i) multiplied by an alpha factor (α).

LO 32.5

Currently, institutions typically only consider a counterparty's probability of default (PD) to the institution (i.e., unilateral CVA). A financial institution should instead consider its bilateral CVA, or the possibility that counterparties could default to the institution and the possibility that the institution could default to its counterparties.

LO 32.6

The formula for calculating CVA across all counterparties is a function of the discounted expected exposure, the risk-neutral marginal probability for a counterparty, and the risk-neutral LGD. The formula depends on market variables, including credit spreads, market spreads, and derivatives values. To calculate a stressed CVA (CVA_S), an instantaneous shock is applied to these market variables. The stress loss is the difference between CVA_S and CVA.

LO 32.7

Financial institutions should incorporate the value of their option to default to a counterparty through the bilateral CVA, also known as the debt value adjustment (DVA).

The BCVA formula differs from the CVA formula in that BCVA incorporates negative expected exposure (NEE) and the probability of the counterparty's survival.

The probability of survival depends on credit default swap spreads, and the losses depend on the institution's own credit spread. The financial institution should consider stress results for the BCVA. Stress losses are calculated by subtracting the value of the current BCVA from the stressed BCVA.

LO 32.8

Shortcomings of stress testing CCR include:

- CCR is not aggregated with loan portfolio or trading position stress tests.
- Stress testing current exposure is not optimal. Instead, institutions should use expected exposure or positive expected exposure.
- Using current exposure can lead to significant errors, especially for at-the-money exposures, when measuring derivatives market values.
- The linearization of delta sensitivities in models can lead to significant errors.

Concept Checkers

1. Which of the following exposure measures reflects the average distribution of exposures at a specific future date prior to the maturity of the longest maturity transaction within a netting set?
   A. Peak exposure.
   B. Current exposure.
   C. Expected exposure.
   D. Expected positive exposure.

2. Is the following statement on the treatment of counterparty credit risk (CCR) correct?

   "Treating CCR as a market risk does not allow an institution to hedge market risk losses, and it exposes the institution to declines in counterparty creditworthiness and default."

   A. The statement is correct with regard to both hedging market risk losses and counterparty creditworthiness and default.
   B. The statement is incorrect with regard to both hedging market risk losses and counterparty creditworthiness and default.
   C. The statement is correct with regard to hedging market risk losses only.
   D. The statement is correct with regard to counterparty creditworthiness and default only.

3. An analyst notes that stress testing current exposure is problematic because aggregating results is typically not meaningful, although it is easy to account for the credit quality of the counterparty. Are the analyst's statements correct?
   A. The analyst is correct with regard to both aggregating results and credit quality.
   B. The analyst is correct with regard to aggregating results only.
   C. The analyst is correct with regard to credit quality only.
   D. The analyst is incorrect with regard to both aggregating results and credit quality.

4. Which of the following statements best reflects the reason why a financial institution does not need to consider aggregating stresses to the expected positive exposure (EPE) with its loan portfolio?
   A. Loans are not sensitive to market variables.
   B. Stresses to EPE are not sensitive to market variables.
   C. The EPE and the loan portfolio are negatively correlated.
   D. The EPE and the loan portfolio are positively correlated.

5. Is the following statement on bilateral credit valuation adjustment (BCVA) correct?

   "The formula for BCVA is similar to the formula for CVA, except that the BCVA formula uses expected positive exposure (EPE) and it incorporates the probability of the counterparty's survival."

   A. The statement is correct with regard to both EPE and probability of survival.
   B. The statement is correct with regard to EPE only.
   C. The statement is correct with regard to probability of survival only.
   D. The statement is incorrect with regard to both EPE and probability of survival.

Concept Checker Answers

1. **C** Expected exposure measures the mean distribution of exposures at a given future date prior to the maturity of the longest maturity exposure in the netting group.

2. **D** Treating CCR as a market risk allows an institution to hedge market risk losses; however, it leaves the institution exposed to declines in counterparty creditworthiness and default. CCR can be hedged by the ongoing replacement of contracts with a counterparty instead of waiting for default to occur.

3. **B** The analyst is correct to state that aggregating stress results is not meaningful. Simply taking the sum of all exposures only considers the loss that would occur if all counterparties were to simultaneously default. This is an unlikely scenario. The analyst's statement on credit quality of the counterparty is incorrect since stresses do not factor in the credit quality of the counterparty.

4. **A** A financial institution does not need to consider aggregating stresses to the EPE with its loan portfolio, because loans are not sensitive to market variables and, therefore, will not have any exposure changes from changes in market variables.

5. **C** The BCVA formula differs from the CVA formula in that BCVA incorporates negative expected exposure (NEE), and the probability of the counterparty's survival must be included in the BCVA formula.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Credit Scoring and Retail Credit Risk Management

Topic 33

Exam Focus

This topic examines credit risk management, primarily from the perspective of the retail credit lender. For the exam, focus on the risks incurred by a lender and how credit scoring models can be used to incorporate variables into an effective risk evaluation model. While estimating risk and evaluating model performance is critical, assessing credit applicants for potential profitability is also important. Be familiar with the role of a credit applicant as both a borrower and a potential client for other lender products. Also, understand the concept of risk-based pricing and how it has changed the way that lenders price their products to different customers.

Retail Banking Risks

LO 33.1: Analyze the credit risks and other risks generated by retail banking.

The retail banking industry revolves around receiving deposits from and lending money to consumers and small businesses. Loans can take the form of home mortgages, home equity lines of credit (HELOCs), installment loans (revolving loans covering automobiles, credit cards, etc.), and small business loans (SBLs). From the perspective of the lending institution, these individual loans constitute small pieces of large portfolios designed to reduce the incremental risk to any one exposure.

The biggest risk associated with retail banking is **credit risk**, which is the likelihood that a borrower will default on debt. Throughout the five years preceding the 2007 subprime mortgage crisis, banks offered customers products they could not afford with risks that were more than customers could bear. **Loan-to-value** (LTV) **ratios** on mortgaged properties were very high and borrowers with weaker credit were given mortgages. These strategies backfired when housing prices collapsed, which resulted in mortgages often exceeding the value of the properties themselves.

Although credit risk is the primary risk in retail banking, several other risks also impact the industry. These risks include:

- **Operational risks**: day-to-day risks associated with running the business.
- **Business risks**: strategic risks associated with new products or trends and volume risks associated with measures like mortgage volume when rates change.
- **Reputation risks:** the bank's reputation with customers and regulators.

- **Interest rate risks**: the bank provides specific interest rates to its assets and liabilities and rates change in the marketplace.
- **Asset valuation risk**: a form of market risk associated with the valuation of assets, liabilities, and collateral classes. An example includes prepayment risk associated with mortgages in decreasing rate environments. Valuation risk also exists in situations when car dealers assume a residual value for a vehicle at the end of the life of a lease.

Retail Credit Risk vs. Corporate Credit Risk

LO 33.2: Explain the differences between retail credit risk and corporate credit risk.

There are several features that distinguish retail credit risk from **corporate credit risk**. As mentioned earlier, retail credit exposures are relatively small as components of larger portfolios such that a default by any one customer will not present a serious threat to a lending institution. A commercial credit portfolio often consists of large exposures to corporations that can have a significant impact on their industry and the economy overall.

Due to the inherent diversification of a retail credit portfolio and its behavior in normal markets, estimating the default percentage allows a bank to effectively treat this loss as a cost of "doing business" and to factor it into the prices it charges its customers. A commercial credit portfolio is subjected to the risk that its losses may exceed the expected threshold, which could have a crippling effect on the bank.

Banks will often have time to take preemptive actions to reduce retail credit risk as a result of changes in customer behavior signaling a potential rise in defaults. These preemptive actions may include marketing to lower risk customers and increasing interest rates for higher risk customers. Commercial credit portfolios typically don't offer these signals, as problems might not become known until it is too late to correct them.

The Dark Side of Retail Credit Risk

LO 33.3: Discuss the "dark side" of retail credit risk and the measures that attempt to address the problem.

An unexpected, systematic risk factor may cause losses to rise beyond an estimated threshold, damaging a bank's retail portfolio through declines in asset and collateral values and increases in the default rate. This represents the "dark side" of retail credit risk.

Primary causes include:

- The lack of historical loss data due to the relative newness of specific products.
- An across the board increase in risk factors impacting the economy overall that causes retail credit products to behave unexpectedly.
- An evolving social and legal system which may inadvertently "encourage" defaults.
- An operational flaw in the credit process due to its semi-automated structure that results in credit granted to higher risk individuals.

The **Consumer Financial Protection Act** (CFPA), in an attempt to manage the dark side of retail credit risk, requires credit originators to evaluate **qualified mortgages** and **ability to repay**.

A borrower with a "qualified mortgage" is assumed to have the capacity to repay. A qualified mortgage will put a limit on the amount of income allocated to debt repayments (e.g., debt-to-income ratio < 45%). A qualified mortgage cannot have excess upfront fees and points, may not be balloon payment loans or interest-only loans, may not be for longer than 30 years, and may not be negative amortization loans.

When a lender is evaluating a customer's "ability to repay," the following underwriting standards must be considered:

- Credit history.
- Current income and assets.
- Current employment status.
- Mortgage monthly payments.
- Monthly payments on mortgage-related items such as insurance and property taxes.
- Monthly payments on other associated property loans.
- Additional debt obligations of the borrower.
- The monthly debt-to-income ratio resulting from the mortgage.

Due to the predictable and relative safety of retail credit, banks must set aside a relatively small amount of risk capital compared to requirements associated with corporate loans. Banks must provide regulators with specific statistics associated with differentiated segments of their portfolios. These statistics include: **probability of default** (PD), **exposure at default** (EAD), and **loss given default** (LGD).

Credit Risk Scoring Models

LO 33.4: Define and describe credit risk scoring model types, key variables, and applications.

A **credit risk scoring model** takes information about an applicant and converts it into a number for the purpose of assessing risk; the higher the number, the higher the probability of repayment by the borrower and the lower the overall risk. Credit scoring models facilitate the gathering of an enormous amount of information into a single automated process.

A credit risk scorecard will gather information from applications and credit bureau reports and weight it depending on the type of questions answered. The question/entry will ask for a specific characteristic like "number of years with current employer," and the attribute will be the response (e.g., 10 years). Credit scoring models will determine positive and negative values and weight each attribute according to past history and the associated probability of repayment.

Three model types exist in regard to scoring applications for consumer credit:

- **Credit bureau scores**: this refers to an applicant's FICO score, and is very fast, easy, and cost effective to implement and evaluate. Scores will typically range from a low of 300 to a high of 850, with higher scores associated with lower risk to the lender and lower interest rates for the borrower.

- **Pooled model**: this model, built by outside parties, is more costly than implementing a credit bureau score model; however, it offers the advantage of flexibility to tailor it to a specific industry.
- **Custom model**: created by the lender itself using data specifically pulled from the lender's own credit application pool. This model type allows a lender to evaluate applicants for their own specific products.

Every individual with a credit history will have credit files containing the following information:

- Personal (identifying) information which doesn't factor into scoring models.
- Records of credit inquiries when a file is accessed. Requests for new credit will be visible to credit grantors.
- Data on collections, reported by entities that provide credit or agencies that collect outstanding debts.
- Legal (public) records on bankruptcies, tax liens, and judgments.
- Account and trade line information gathered from receivables information sent to credit bureaus by grantors.

Mortgage Credit Assessment

LO 33.5: Discuss the key variables in a mortgage credit assessment and describe the use of cutoff scores, default rates, and loss rates in a credit scoring model.

In assessing an application for mortgage credit, the key variables include:

- **FICO score**: a numerical score serving as a measure of default risk tied to the borrower's credit history.
- **Loan-to-value** (LTV) **ratio**: the amount of the mortgage divided by the associated property's total appraised value.
- **Debt-to-income** (DTI) **ratio**: the ratio of monthly debt payments (mortgage, auto, etc.) to the monthly gross income of the borrower.
- **Payment** (pmt) **type:** dictates the type of mortgage (adjustable rate, fixed, etc.)
- **Documentation** (doc) **types**, which include:
  - *Full doc*: a loan which requires evidence of assets and income.
  - *Stated income*: employment is verified but borrower income is not.
  - *No ratio*: similar to stated income, employment is documented but income is not. The debt-to-income ratio is not calculated.
  - *No income/no asset*: Income and assets are provided on the loan application but are not lender verified (other than the source of income).
  - *No doc*: no documentation of income or assets is provided.

Cutoff Scores

Cutoff scores represent thresholds where lenders determine whether they will or will not lend money (and the terms of the loan) to a particular borrower. As noted earlier, the higher the score, the lower the risk to the lending institution. Setting the cutoff score too low presents a higher risk of default to the lender. Setting the cutoff score too high may limit potential profitable opportunities by unintentionally eliminating low risk borrowers.

Once the cutoff score is established, historical experience can be used to establish the estimated profitability for a specific product line and the associated loss rate. As estimates are made from longer time horizons (which hopefully capture a full economic cycle), a bank may adjust its cutoff score to maximize the appropriate balance between risk and profitability.

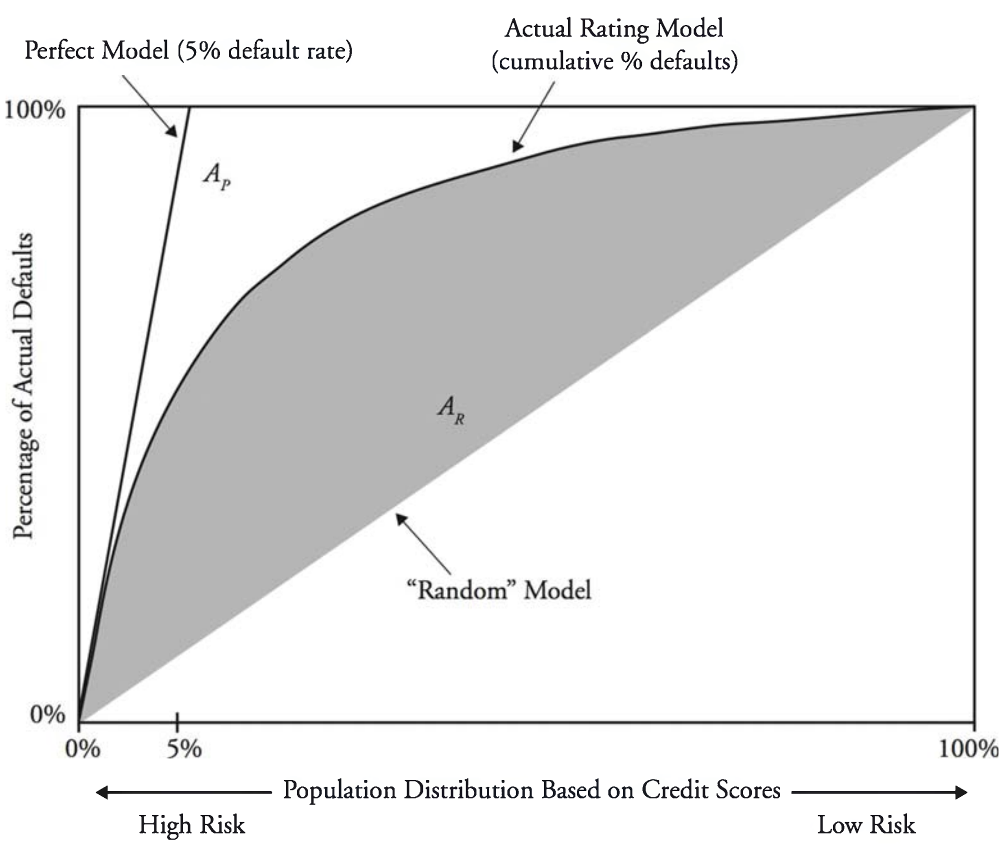
Banks are required by the Basel Accord to group their portfolios into subgroups that share similar loss attributes, with score bands used to differentiate the groups by risk levels. For each of these subgroups, banks are required to estimate the PD and the LGD. The implied PD is a by-product of the historical loss rate and the LGD such that if a portfolio has a loss rate of 3% with a 75% LGD, then the PD is 4% (i.e., 3%/75% = 4%).

Scorecard Performance

LO 33.6: Discuss the measurement and monitoring of a scorecard performance including the use of cumulative accuracy profile (CAP) and the accuracy ratio (AR) techniques.

Credit scoring is used as a means of predicting default risk, such that high (low) scores on the scorecard are assigned to strong (weak) credits. In assessing the performance of the scorecard, a **cumulative accuracy profile** (CAP) and the **accuracy ratio** (AR) are often used. The CAP shows the population distribution based on credit scores (and therefore risk) versus the percentage of actual defaults.

Figure 1: Cumulative Accuracy Profile and Accuracy Ratio



Lines plotted on the graph include the perfect model line, random model line, and observed cumulative default percentage line defined as follows:

- In a perfect model, if the bank predicts, for example, 5% of its accounts will default over a specific period, 100% of those defaults will come from the riskiest 5% of the population.
- A random model will assume 5% of the defaults will come from the riskiest 5%, 20% will come from the riskiest 20%, etc.
- The observed cumulative default line represents the actual defaults observed by the bank.

The area between the perfect model and the random model is represented by A_P, while the area between the observed cumulative default percentage line and the random line is represented by A_R. The accuracy ratio (AR) is defined as A_R/A_P, with a ratio close to 1 implying a more accurate model.

A scoring model must be monitored on a regular basis due to underlying changes in the population as well as potential product changes.

Tradeoff between Creditworthiness and Profitability

LO 33.7: Describe the customer relationship cycle and discuss the trade-off between creditworthiness and profitability.

Entities in the business of loaning money do not focus entirely on risk and creditworthiness; they also have to evaluate customers from the perspective of profitability. If a credit card is issued to a customer with a very high FICO score who pays their bill in full every month, the bank will not earn any interest from that customer on borrowed funds. At the same time, issuing that same credit card to a customer with a low FICO score is a greater risk because the customer may be unable to pay back loaned funds. Along with credit default scoring, lenders are using product and customer profit scoring measures to evaluate the potential profitability of a specific product and the potential profitability of a specific customer.

In utilizing scorecards to evaluate customers, there are several variations beyond just the credit bureau (FICO) scores. These additional scorecards can be used to evaluate both creditworthiness and profitability. They include:

- *Revenue scores*: used to evaluate existing customers on potential profitability.
- *Application scores*: used to support the decision to extend credit to a new applicant.
- *Response scores*: assign a probability to whether a customer is likely to respond to an offer.
- *Insurance scores*: assign a probability to potential claims by the insured.
- *Behavior scores*: assess existing customer credit usage and historical delinquencies.
- *Tax authority scores*: predict where potential audits may be needed for revenue collection.
- *Attrition scores*: assign a probability to the reduction or elimination of outstanding debt by existing customers.

The **customer relationship cycle** involves the process a lender goes through to market its products/services, screen applications from customers, manage customer accounts, and then cross-sell to those customers. Marketing efforts will focus on selling new or tailoring existing products to meet the needs of both new and existing customers. Applicant screening involves the acceptance or rejection of an application based on scorecards noted previously,

as well as ultimately determining the appropriate price to charge for accepted applicants. Managing the customer account will primarily involve product pricing, credit line authorizations, modifications, renewals, and principal or interest collections. Cross-selling efforts will target existing customers by offering other lender products to meet their needs.

Risk-Based Pricing

LO 33.8: Discuss the benefits of risk-based pricing of financial services.

Recognizing that charging a single price for a product to all customers regardless of risk levels may lead to adverse selection (i.e., high-risk customers attracted to a relatively low price relative to their risk profile and low-risk customers pushed away by the higher price relative to their risk profile), lenders have been moving toward **risk-based pricing** (RBP). RBP involves lenders charging different customers different prices based on their associated risks. Although RBP is still in the early stages of implementation in the financial retail sector, it has been utilized more frequently in credit card, home mortgage, and auto loan lines.

Key external and internal factors which account for risk and play into the interest rates and prices charged by lenders include:

- The probability of **take-up** (i.e., acceptance by the customer of the offered product).
- The probability of default (PD).
- The loss given default (LGD).
- The exposure at default (EAD).
- The cost of equity capital to the lender.
- Capital allocated to the transaction.
- Operating expenses of the lender.

Prices may be set on a tiered level based on score bands allocating risks from high to low. The lender can then map pricing strategies to metrics such as profit/loss, revenue, market share, and risk-adjusted return at the various score bands. Utilizing RBP effectively allows management to evaluate the inevitable tradeoffs among profitability, market share, and risk with the short and long-term goal of increasing shareholder value.

Key Concepts

LO 33.1

Retail banking involves the acceptance of deposits and lending of money to customers. Credit risk (the probability that a borrower will default on debt obligations) represents the biggest risk in retail banking. Other risks include operational risks, business risks, reputation risks, interest-rate risks, and asset valuation risk.

LO 33.2

Retail credit risk differs from corporate credit risk in the following significant ways:

- Retail exposures are relatively small such that one default has minimal impact, whereas commercial exposures are much larger and single defaults can have a significant impact.
- Losses exceeding expected thresholds can have a much greater impact for corporate portfolios than retail portfolios.
- Lenders can take preemptive actions to reduce retail credit risks, whereas commercial portfolios often send warning signals after it is too late.

LO 33.3

The "dark side" of retail credit risk occurs when a large scale risk factor causes a decline in asset values coupled with an increase in default rates. The end result is losses which exceed an estimated threshold. Lenders offering mortgage loans must evaluate customers' ability to pay as well as determining whether a mortgage is "qualified." In addition, banks must segment their portfolios and set aside risk capital as well as assess exposures and probabilities of default along with potential losses.

LO 33.4

A credit risk scoring model assigns (to each credit applicant) a score which serves as a measure of borrower risk; the higher (lower) the score, the lower (higher) the risk that the borrower won't be able to pay the debt obligation. Models include credit bureau scores, pooled models, and custom models which all use applicant data and weight them based on their historical relationship to potential defaults.

LO 33.5

Key variables associated with mortgage credit applications include FICO scores, loan-to-value ratios, debt-to-income ratios, payment types, and documentation types. Cutoff scores are thresholds set by lenders which dictate whether credit will or will not be extended, as well as terms associated with the loans. Probability of default and loss given default metrics are critical to assessing the risk associated with various lender portfolios.

LO 33.6

The cumulative accuracy profile (CAP) and the accuracy ratio (AR) are used to assess the performance of a credit scorecard. The closer the accuracy ratio is to 1, the more accurate the CAP model is at predicting the distribution of defaults relative to the risk levels of the associated population.

LO 33.7

For new and existing credit applicants, lenders may use a variety of scorecards to evaluate both creditworthiness and potential profitability. The customer relationship cycle involves marketing products, screening applicants, managing customer accounts, and eventual cross-selling to an existing customer base.

LO 33.8

Risk-based pricing (RBP) involves charging different prices for the same product such that higher (lower) prices can be charged to higher (lower) risk customers. Several external and internal factors are used to determine the prices charged, which are then evaluated in conjunction with various key performance metrics at each score (risk) band in order to maximize the tradeoff between risk and profitability.

Concept Checkers

1. Which of the following statements is most accurate regarding risks incurred by retail lenders?
   A. Reputation risk is more of a concern for the borrower rather than the lender.
   B. Business risk relates to the day-to-day operational risks of the business.
   C. Credit risk relates to the potential for a lender to default on their obligation.
   D. Refinancing a mortgage when rates decrease is an example of asset valuation risk.

2. The dark side of retail credit risk is perpetuated by all of the following factors except:
   A. capital set aside to protect a bank in the event of default.
   B. process flaws resulting in high risk applicants receiving credit.
   C. new products which do not have sufficient historical loss data.
   D. a social acceptance of bankruptcy and borrowers "walking away" from their obligations.

3. Which of the following statements is correct regarding credit risk scoring models?
   A. A pooled model will result in scores ranging from 300 to 850.
   B. A custom model is cheaper to implement than credit bureau scores.
   C. Multiple requests for new credit will reduce an applicant's credit score.
   D. An example of a characteristic in a scoring model is the applicant's current gross salary of $50,000.

4. In assessing the key variables associated with a potential mortgage loan, a bank will charge a higher interest rate if the borrower has a relatively:
   A. high FICO score.
   B. high loan-to-value ratio.
   C. low debt-to-assets ratio.
   D. low debt-to-income ratio.

5. By implementing risk-based pricing on its mortgage products, a bank will likely charge a:
   A. higher interest rate to a customer with a higher FICO score.
   B. lower interest rate to a customer with a lower credit bureau score.
   C. higher interest rate to a customer with a higher probability of default.
   D. lower interest rate to a customer positioned on a lower relative score band.

Concept Checker Answers

1. **D** Refinancing a mortgage is considered a prepayment risk to the lender, which is a component of asset valuation risk. When rates decrease, borrowers are more likely to refinance their existing (higher rate) mortgage into a lower rate obligation. The lender then earns less in interest on the debt obligation than they would have previously. Reputation risk is primarily a concern for the lender. Business risk relates to strategic risks tied to new products and volume, while credit risk is the risk that the borrower (rather than the lender) will default.

2. **A** Capital must be set aside to protect banks in the event of default, but this is a response to the dark side of retail credit risk rather than a perpetuating factor. A process flaw which grants credit to high risk individuals, a new product which doesn't have historical loss data, and the social "acceptance" of failing to meet debt payments are all considered perpetuating factors of retail credit risk.

3. **C** An individual's credit file will show a history of credit requests, with multiple requests causing an applicant's credit score to decline. A credit bureau score model (rather than pooled model) will result in scores ranging from 300 to 850. A custom model is more expensive to implement than credit bureau scores. "Gross salary with current employer" is an example of a characteristic, with the actual salary number itself representing an attribute.

4. **B** The loan-to-value ratio represents the amount of the mortgage versus the appraised value of the property. The higher this ratio is for a property and an associated borrower, the more risk there is to the lender. In order to protect their position, a lender will charge a higher interest rate. Each of the other scenarios will result in a lower interest rate.

5. **C** The more likely it is that a customer will default, the higher the interest rate the bank will charge. A customer with a higher (lower) FICO/credit bureau score will be offered a lower (higher) interest rate. A customer positioned on a lower relative score band will be offered a higher interest rate.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

The Credit Transfer Markets—and Their Implications

Topic 34

Exam Focus

Securitized financial products became very popular prior to the 2007–2009 financial crisis. Although it is important for investors to understand the inner workings and risk potential inherent in any investment before adding it to a portfolio, more complex assets such as securitized products demand even more scrutiny. For the exam, be able to identify flaws in the securitization of subprime mortgages, and be able to explain the different techniques used to mitigate credit risk. Also, be able to describe the different types and structures of credit derivatives, including credit default swaps (CDSs), first-to-default puts, total return swaps (TRSs), and asset-backed credit-linked notes (CLNs). It is also important to be familiar with the structures of collateralized debt obligations (CDOs), synthetic CDOs, and single-tranche CDOs.

Flaws in the Securitization of Subprime Mortgages

LO 34.1: Discuss the flaws in the securitization of subprime mortgages prior to the financial crisis of 2007.

The financial credit crisis of 2007 is thought by some to have been caused by the process of transferring credit risk. However, during the credit crisis, the credit risk transfer mechanism did perform its intended function. The true issue was not the credit risk transfer process itself, but rather the underlying flaws in the pre-crisis securitization process.

Securitization in its most basic form is simply using financial engineering to repackage a pool of assets into a new asset that can be sold to investors. This innovation enables banks to transfer the credit risk inherent in mortgage lending to investors through mortgage-backed securities and similar investments. This process enhances the availability of loanable funds for borrowers, expands the pool of diversification options for investors, and minimizes the borrowing costs for a given risk-class of borrowers.

The securitization process enabled an active **originate-to-distribute model** where banks could originate a loan for the sole purpose of turning a quick profit and selling the securitized product to investors. This creates a conflict of interest because every link in the securitization chain, from the originator to the lender to the investment banker to the credit rating agency, had the potential to earn a relatively quick, short-term profit through securitization without retaining any of the risk, which was ultimately outsourced to investors. The gains in the securitization supply chain were linked solely to deal completion and not to the potential risk of the borrowers. In this process, U.S. financial institutions

misjudged the liquidity and credit concentration risks inherent in mortgage lending. This paradoxical deviation from the traditional risk-reward tradeoff created less incentive to monitor the creditworthiness of borrowers and reduced accountability. It is one of the key flaws in the securitization process.

Professor's Note: According to the Joint Center for Housing Studies at Harvard University, from 2001 to 2006, conventional mortgages (30-year, fixed rate mortgages) fell from 57.1% of all loan originations to 33.1%. Subprime loans rose from 7.2% to 18.8%! Approximately 40% of all mortgages purchased by Fannie Mae and Freddie Mac, from 2005 to 2007, were subprime loans. Demand increased substantially for loans built with adjustable interest rates, zero down payments, and no documentation of income sources.

Another flaw in the securitization process is the opaqueness of the end product. Neither investors nor the rating agencies, whom the investors relied upon, fully understood how to evaluate the multilayered securitized products. Investors did not fully understand either the credit quality of the underlying loans or the potential correlation within the loan pool should an unexpected shock occur. This created a very fragile system based on trust, which was later broken when the expected low default rates exceeded a margin of safety.

A third flaw is that as time progressed without any initial problems, many banks elected to start retaining the risk of structured products. In fact, in mid-2007, U.S. financial institutions directly held $900 billion of subprime mortgage-backed products on their books. They used rolling short-term debts to finance purchases of long-term mortgage-backed structured products in off-balance-sheet entities known as **structured investment vehicles** (SIVs) partly because mortgages earned much higher returns than corporate bonds. Banks thought that they were earning a riskless spread over corporate bonds with comparable ratings. By using a leveraged SIV instead of holding the actual loans on their balance sheets, banks were able to use far less capital to hold a pool of mortgages. On one hand, this flaw appears to be a partial correction for the first flaw. Banks did start to retain some risk, but they used a mechanism that still prevented investors from evaluating the full extent of the risk.

In fairness, banks sometimes used SIVs as a warehouse for unsold structured products that were waiting to be matched with a willing buyer, but more often, the securitized products were seen as a sound investment by themselves. Some of the largest buyers of securitized U.S. subprime loans were European banks. For example, in 2006, subprime securities accounted for 90% of the profits of Sachsen Landesbank in Leipzig, Germany. This bank probably does not sound familiar, because it is no longer in existence. The bank ceased operations in 2007 due to its excessive level of leveraged risk exposure.

When structured with transparency, the credit risk transfer mechanism should assist the price discovery process for credit risk. If the three flaws identified can be adequately addressed, then financial institutions can once again use the credit transfer process to effectively manage risk.

Credit Risk Mitigation Techniques

LO 34.2: Identify and explain the different techniques used to mitigate credit risk, and describe how some of these techniques are changing the bank credit function.

When conducted properly, the credit risk transfer process can be revolutionary for financial institutions. Proper techniques can include bond insurance, collateralization, termination, reassignment, netting, marking to market, syndication of loan origination, or outright selling of a loan portfolio in the secondary market.

As its name suggests, **bond insurance** is a formal process of purchasing insurance against the potential default of an issuer. In the corporate debt market, it is the lender who needs to purchase default protection. However, in the municipal bond market, insurance is purchased by the issuer of the municipal obligation. Approximately one third of all municipal bond offerings are covered by insurance. This insurance coverage enables these municipalities to issue debt at reduced rates. Some issuers also need to utilize guarantees and letters of credit, which are both de facto forms of insurance. These tools involve a third party with a higher credit rating than the issuer agreeing to make good on any deficiencies should the issuer default.

The use of **collateralization** is perhaps the longest running form of credit risk mitigation. The losses sustained by the lender will be offset by the value of the collateral in the event of a default. One issue that needs to be considered is liquidity of the collateral. Liquidity is the ability to turn an asset into cash quickly while retaining reasonable value. In the 2007–2009 financial crisis, we learned that mortgage lending, while secured with real estate as collateral, is riskier than it sounds because the same risk event that triggered the default of securitized loans also caused the value of the collateral to deteriorate.

Another risk mitigation option is **termination**. Using this tool means that the debt obligation is canceled prior to maturity at a mid-market quote. Usually, this means that a certain trigger event, such as a downgrade, has occurred and the issuer was obligated to repay the loan early. An alternative to outright termination is known as **reassignment**, which gives the right to assign one's position as a counterparty to a third party if a trigger event occurs.

Sometimes a counterparty will enter into numerous derivative transactions with the same financial institution. Some of these derivatives will have a positive replacement value while others will have a negative replacement value. All over-the-counter (OTC) derivatives transactions between common counterparties can be aggregated together so that the net replacement value represents the true credit risk exposure. This process is known as **netting**.

Marking to market is another option. This tool involves periodically acknowledging the true market value of a transaction. This transparency will result in immediately transferring value from the losing side to the winning side of the trade. This process is extremely efficient, but it does require sophisticated monitoring technology and back-office systems for implementation.

Some financial institutions also utilize **loan syndication** when an issuer needs to raise a significant amount of capital or perhaps the credit risk is more than a single lender would

choose to absorb. The syndication process will involve multiple lenders all working together as a team to provide funding to a given borrower. The lead syndicator will receive a fee from the issuer for arranging the syndicate.

Professor's Note: According to the Federal Reserve Bank of New York, the syndicated loan market grew from $339 billion in 1988 to $2.2 trillion in 2007.

Typically, syndicated loans end up being traded on the secondary markets, and there is an emerging trend for certain entities (e.g., insurance companies) to match the duration of their long-term liabilities with loan pools purchased from banks. These are secondary market transactions. This innovation can mitigate risk for the loan-originating bank and also the insurance company at the same time. The risk reduction is not limited to insurance companies. Secondary market transactions are being used for risk mitigation at all financial institutions.

The traditional model of the **bank credit function** is changing as a result of these credit risk mitigation techniques. Traditionally, banks would hold credit assets, like loans, until they matured. As such, banks focused on estimating the expected loan losses using the notional value of the loan and the probability of default (PD). These expected losses formed the basis of loan loss reserves held on the bank's balance sheet and were explicitly priced into the spread charged on the loan over the bank's funding costs. However, the real world has proven that there are many unexpected events that are not captured by normal probability estimates.

Sometimes unexpected events materialize because of credit concentration in loan pools. Many banks become highly concentrated either in their geographic dispersion of loans, their industry exposure, or even in a small number of issuers due to a special relationship with the bank. One of the credit department's key responsibilities is to increase the velocity of capital by using lower cost borrowing to facilitate more profitable opportunities. Credit mitigation techniques enable banks to continue extending credit to riskier borrowers and to more concentrated pools of issuers and then transfer the credit risk to keep overall risk within an acceptable margin.

The Originate-to-Distribute Model of Credit Risk

LO 34.3: Describe the originate-to-distribute model of credit risk transfer and discuss the two ways of managing a bank credit portfolio.

Over the last two decades, portfolios of loans in the banking industry have become much more concentrated in less creditworthy borrowers. During periods of crisis, default rates increase and this creates significant losses for debtholders. In 1990, defaults cost approximately $20 billion, while in 2009 they cost $628 billion. At the same time, banks have developed strong relationships with large corporate borrowers and robust distribution networks for securitized loan transactions. These realities coupled with Basel capital adequacy standards have led financial institutions to switch from traditional, originate-to-hold, lending models to the portfolio-based, originate-to-distribute (OTD), model.

OTD models have produced three primary benefits. The first benefit is that loan originators enjoy increased capital efficiency and decreased earnings volatility because the credit risks have been largely outsourced. The second benefit is that investors have a wider array of diversification options for the fixed income portion of their portfolios. The third benefit is that borrowers have expanded access to credit and lowered borrowing costs. From one vantage point, the 2007–2009 financial crisis occurred partly because banks did not pursue these three benefits through a pure OTD model, but instead held very concentrated risks on their balance sheets through SIVs.

Professor's Note: According to the Federal Reserve Bank of New York, in 1988, 21% of term loans originated by a lead syndicator were held on their balance sheet. This percentage declined to 6.7% in 2007 and 3.4% in 2010.

Under the traditional originate-to-hold (OTH) lending model, credit assets are retained at the business unit level. Loans are originated using a binary (accept or reject) approval process. At loan origination, risk is measured based on notional value and then left unmonitored thereafter. The compensation structure in the OTH system is based on loan volume. More loans mean more profit potential.

At its core, the OTD model involves dividing loans into two groups: core loans and non-core loans. The bank will typically hold the core loans and either securitize or outright sell the non-core loans it has originated. Here, loan origination focuses on charging a sufficient risk-adjusted spread over the bank's hurdle rate. After origination, the OTD model transfers credit assets to the credit portfolio management group who monitors the apparent risks until the asset is transferred off the originator's books. One key function of the credit portfolio management group is to monitor credit risk concentrations and to outsource any risks that could potentially threaten bank solvency. Some credit portfolio strategies are therefore based on defensive risk mitigation and not solely on a profit motive. Ultimately, all returns are measured in a risk-adjusted format and compensation is based on risk-adjusted performance.

The OTD model enables financial institutions to provide access to capital for less creditworthy borrowers and then subsequently sell or hedge their lending risks through the use of credit risk mitigation techniques and credit derivatives.

Credit Derivatives

LO 34.4: Describe the different types and structures of credit derivatives including credit default swaps (CDS), first-to-default put, total return swaps (TRS), asset-backed credit-linked note (CLN), and their applications.

One critique of traditional credit risk mitigation techniques is that they do not unbundle the credit risk from the underlying asset. Credit derivative products, such as credit default swaps, first-to-default puts, total return swaps, and asset-backed credit-linked notes, are over-the-counter financial contracts that respond directly to this critique. Payoffs for these instruments are contingent on changes in the credit performance or quality of a specific underlying issuer. Therefore, these tools directly enable one party to transfer the credit risk

of a reference asset to another party without ever selling the asset itself. In doing so, credit derivative products also aid in price discovery aimed at isolating the economic value of default risk.

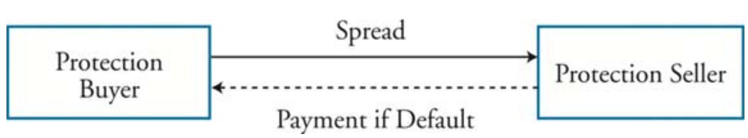
Consider an example of the usefulness of credit derivatives. Bank A specializes in lending to the airline industry, while Bank B specializes in lending to energy firms. When energy prices are high the energy firms tend to do well, while airlines languish. The reverse is true when energy prices are low. Bank A and Bank B could mitigate their credit risk by either directly selling 50% of their loans to each other, or they could use credit derivatives to more cost effectively meet the same need.

Investors and financial institutions can use credit derivatives to accomplish several different goals. Credit derivatives can provide access to specialized risk factors for both risk mitigation and for speculation. As previously mentioned, these credit products also unbundle credit risk from ownership of an underlying asset, effectively creating two unique tradable assets. Credit derivatives also provide yield enhancement and a mechanism to hedge industry-specific and country-specific risks borne by an investor or institution. Hedge funds, and other speculative investors, also use credit derivatives to exploit arbitrage opportunities.

Credit Default Swaps

The most popular form of credit derivative is the **credit default swap** (CDS). A CDS is customizable insurance against the default of some underlying asset. It is a de facto put option on the underlying asset. The protection buyer is trying to outsource credit risk, while the protection seller is actually buying credit risk by providing the insurance. Think of the protection buyer like a put buyer and the protection seller like a put seller. The protection buyer will make pre-specified payments to the protection seller over a pre-specified time period and the protection seller is liable for making the protection buyer "whole" if a credit event occurs. Hence, a single-name CDS operates essentially as an insurance contract but a key difference is that the protection buyer need not actually own the underlying asset. Figure 1 illustrates the mechanics of the single-name CDS.

Figure 1: CDS Structure



For example, if an institutional investor owned $100 million of a certain company's debt and wanted to protect himself from a potential default, the investor could enter into a CDS contract with 150 basis points with quarterly payments. That means that the investor would pay $375,000 [(1.5% × $100,000,000) / 4] every quarter for the length of the contract. The length of a CDS contract is usually much less than the duration of the underlying asset. If this debt instrument matured in 15 years, then the CDS contract might have a 2–3 year tenure. If this debt issuance has a yield of 4.5% then this protection buyer has enabled a 3.0% annual return without any default risk for the tenure of the CDS contract.

Professor's Note: According to the Bank for International Settlements (BIS), credit default swaps were virtually non-existent in 1997, ballooned to $62.2 trillion in 2007, and subsequently fell to approximately $16 trillion of notional value by the end of 2014.

Why would an investor pay for credit default protection using a CDS contract? Obviously, they are concerned about a negative credit event impacting the value of the underlying asset. Payment to the protection buyer is triggered with several potential credit events. The first potential trigger event is bankruptcy. Payment can also be triggered by a specified drop in the value of the underlying asset that does not include bankruptcy. Downgrade below a certain threshold and unfavorable debt restructure can also result in a payment. The International Swaps and Derivatives Association (ISDA) has the final say on whether a credit event has officially triggered a CDS payment.

If a payment is triggered, the payment could be made in one of three ways. The first payment option is the par value of the underlying asset minus the post-default price. This is essentially a "make me whole" payment. The second payment option is par value minus a stipulated recovery factor. Most corporate bonds have a contractually stipulated 40% recovery rate. This means that the CDS was priced so that the most that a protection buyer could recover is 60% of the notional principal. The third payment option is the full payment of the par value, without any subtractions, but the protection buyer must also physically deliver the underlying asset to the protection seller. This is also a "make me whole" payment.

Credit default swaps can be used for risk management, but they can also be used for direct speculation. During the months and years leading up to the 2007–2009 financial crisis, some savvy investors who saw trouble on the horizon purchased CDS contracts against the default of various companies. In this way, these investors were using CDS contracts to replicate put options. However, the CDS contract is only as good as the creditworthiness of the counterparty. This risk should be considered as well. Lehman Brothers and American International Group (AIG) were two significant counterparties that did not weather the financial crisis very well.

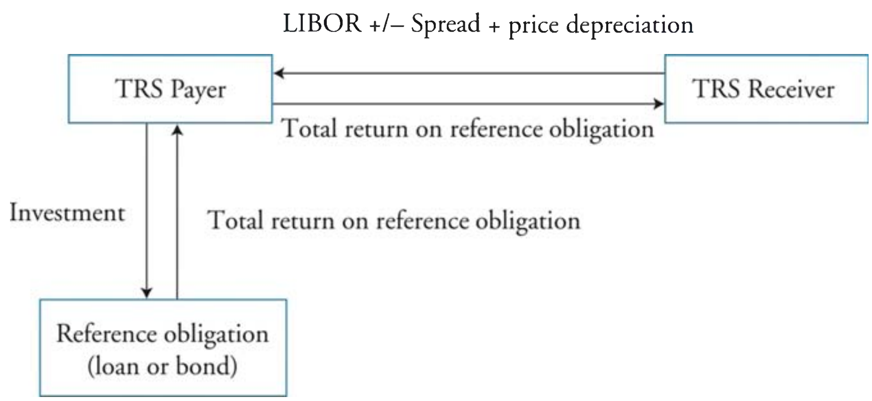
First-to-Default Puts

A variation of the CDS is known as a **first-to-default put**. To explain this innovation, it will be easiest to consider a bank that holds four different B-rated high yield loans. Each loan has notional principal of $100 million, a five-year maturity, and an annual coupon of LIBOR plus 250 basis points. The idea is that this pool of loans has very low default correlations. The bank could purchase a first-to-default put for two years at perhaps 400 basis points. This means that the bank would pay $4 million annually for two years. In return for this "insurance" premium, the bank would be made whole in the event that any one of the four bonds defaulted. If two bonds default, then they still are only paid for the first bond and the second becomes a loss event. This is a much more cost effective option for the bank if the loans truly have uncorrelated default risks. The cost of the first-to-default put will lie between the cost of a CDS on the riskiest bond and the total cost for a CDS on all bonds.

Total Return Swaps

While a CDS contract outsources only the credit risk, a **total return swap** (TRS) outsources both credit risk and market risk. A TRS is designed to mirror the return on an underlying investment, such as a loan, a floating rate note, a coupon bond, a stock, or a basket of assets. There are two parties to a TRS contract. The "payer" is the owner of the underlying asset. The payer will agree to pay the underlying asset's total return, including any price appreciation and coupon or dividend payments, to a "receiver." The receiver is responsible to pay the payer for any depreciation in the asset. The receiver will also pay LIBOR plus a predetermined spread to the payer regardless of what happens with the reference asset.

Figure 2: Total Return Swap Structure



In essence, the receiver is taking a synthetic long position in the underlying asset without actually owning the underlying. Tremendous leverage can be applied by the receiver because they do not need to invest the notional principal. They only need enough money to make payments when due. Hedge funds are one common receiver counterparty in TRS contracts. Banks are usually the payer counterparties because they have access to capital to purchase the underlying assets but are looking to remove credit and market risk exposure from their balance sheets.

Asset-Backed Credit-Linked Notes

A further innovation called an **asset-backed credit-linked note** (CLN) embeds a default swap into a debt issuance. A CLN is a debt instrument with its coupon and principal risk tied to an underlying debt instrument, like a bond, a loan, or a government obligation. Unlike a CDS contract, principal is exchanged when a CLN is sold to an investor, although the CLN seller retains ownership of the underlying debt instrument.

A CLN is best understood with an example. Assume there is a hedge fund that wants to capture $125 million of exposure to a fixed income instrument, but it only wants to invest $25 million as collateral. A bank agrees to help in the process. The bank will borrow $125 million at LIBOR and purchase the reference asset, which is currently yielding LIBOR plus 250 basis points. The reference asset is placed in a trust, which then issues a CLN to the hedge fund. The hedge fund will then give the bank $25 million, which is invested in a risk-free U.S. government obligation yielding 4%. This investment now represents the collateral

on the bank's borrowing. That means there is 20% ($25 million / $125 million) of collateral and a leverage multiple for the hedge fund of 5 times ($125 million / $25 million).

Remember that the reference asset is yielding LIBOR plus 250 basis points. The bank will keep LIBOR plus 100 basis points, using the LIBOR return to fund the cost of acquiring the reference asset and the additional 100 basis points as compensation for assuming the risk of default above the collateral of $25 million. The hedge fund will receive the 4% earned on the $25 million of collateral ($1 million) and will also receive the additional 150 basis point spread over the funding cost on the full $125 million ($1.875 million in additional return). This means that the hedge fund has captured an 11.5% leveraged return [($1 million + $1.875 million)/$25 million initial investment]!

There are no margin calls with a CLN, but there is still risk on the table for the hedge fund and for the bank. Should the reference asset lose more value than the $25 million in collateral, the hedge fund will default on its CLN obligation and lose the full $25 million investment. The bank will be responsible for any losses greater than the $25 million of hedge fund collateral. Thus, the bank will likely look to outsource this risk using a CDS contract.

The Credit Risk Securitization Process

LO 34.5: Explain the credit risk securitization process and describe the structure of typical collateralized loan obligations (CLOs) or collateralized debt obligations (CDOs).

The credit risk securitization process is a technique that uses financial engineering to combine a segregated pool of assets into one tradable security with various inherent risk levels. The company that starts this process is called the **originator**. The originator will purchase a series of different assets, like corporate bonds, leveraged loans, mortgages, auto loans, or perhaps credit card loans. These assets are held on the originator's balance sheet until they have a sufficient quantity of assets to repackage this pool into a security.

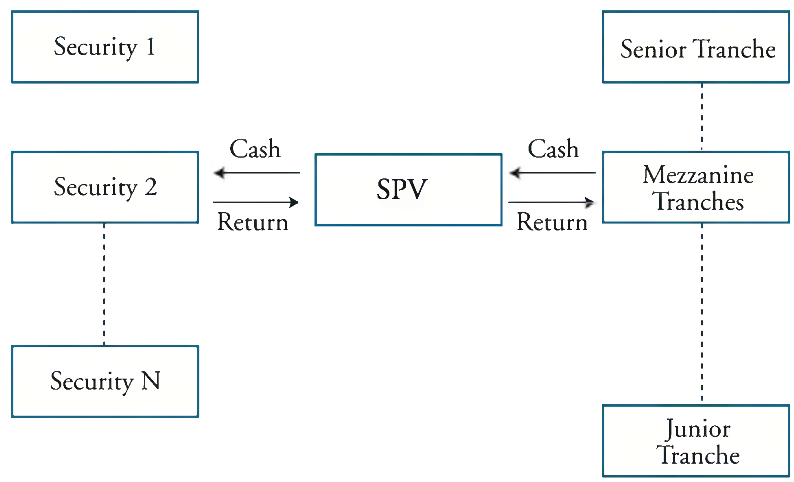
The actual repackaging process occurs in an off-balance-sheet entity, like a **special purpose vehicle** (SPV). Once assets are transferred to the SPV, securities must be issued, based on this reference pool of assets, to fund the purchase of the assets. The securitized asset is structured in such a way that the originator has no recourse for losses sustained after an investor purchases a securitized asset.

Part of the securitization process also involves establishing various risk layers within the new investment product. These layers are called **tranches**. The senior tranches have the lowest risk of loss. There are several mezzanine tranches as well. The idea is that in the event of default by the underlying assets, the most junior tranches will realize the loss first. In fact, the senior tranches will not experience any loss unless the more junior tranches all experience 100% losses. This cash loss process is sometimes called the "waterfall" structure of securitized products and it provides an apparent safety margin for the senior tranches.

There is a very broad category of securitized products known as **collateralized debt obligations** (CDOs). In general, a CDO is an asset-backed security that can branch into corporate bonds, emerging market bonds, residential mortgage-backed securities (RMBS),

commercial mortgage-backed securities (CMBS), real estate investment trust (REIT) debts, bank loans, other forms of asset-backed securities backed by auto and credit card loans, and even other CDOs.

Figure 3: A CDO With *N* Underlying Securities



Perhaps the most well-known form of a CDO is called a **collateralized loan obligation** (CLO). CLOs focus on repackaging high-yield bank loans. With a CLO, below-investment-grade bonds are restructured into tranches, which include investment-grade senior tranches, a junior equity tranche, and possibly intermediate-quality tranches between the senior and junior tranches (i.e., mezzanine tranches). The senior tranches achieve investment-grade ratings by effectively outsourcing the default risk to the equity tranche. This allows the originator of the high-yield loans to sell the senior tranches to insurance companies and pension funds, which are required to own investment-grade debt instruments. It is also important to note that bank loans are amortizing, which means they have a shorter duration than corporate bonds with similar maturities.

Consider an example of the CLO repackaging process. A bank compiles $1 billion in high-yield loans that are below investment-grade. This group of loans will meet certain parameters, such as the number of industries represented in the loan pool, the maximum percentage in any given industry, and the maximum percentage in any given issuer. This data will communicate risk to potential investors. The bank will securitize this CLO into perhaps three tranches. A senior secured tranche class A, a senior secured tranche class B, and a residual or equity tranche that is subordinate. The weighted average life of the loans in the CLO is six years with an average coupon of LIBOR plus 250 basis points. The senior class A notes will have a face value of $850 million, a 12-year maturity, a coupon of LIBOR plus 40 basis points, and a robust investment-grade rating. The senior class B notes will have a face value of $60 million, a 12-year maturity, a coupon of LIBOR plus 150 basis points, and a low-end investment-grade rating. The subordinated equity tranche will have a face value of $90 million, a 12-year maturity, a residual claim on any CLO assets, and a non-investment-grade rating.

During the first six years of this example CLO, loans begin to mature. However, the tranches all have a 12-year maturity. The CLO originator will reinvest the maturing proceeds in additional six-year loans adhering to the initial industry and concentration risk

stipulations. After this initial rebalancing, the CLO investors will begin to receive principal repayments as the loans mature. The first in line will be the senior class A notes. Since the underlying high-yield loans are paying such a high spread over what the senior tranches will receive, the equity tranche has the potential to earn a very substantial return if defaults do not materialize. Typically, the originating bank will retain the equity tranche to keep a small amount of skin in the game.

Synthetic CDOs and Single-Tranche CDOs

LO 34.6: Describe synthetic CDOs and single-tranche CDOs.

In a traditional CDO, which is also called a "cash CDO," the credit assets owned by the SPV are fully funded with cash, and the repayment of the obligation is tied directly to cash flow from the underlying debt instruments. There is an alternative form of CDO called a **synthetic CDO**, which takes a different approach. With a synthetic CDO, the originator retains the reference assets on their balance sheet, but they transfer credit risk, in the form of credit default swaps, to an SPV which then creates the tradable synthetic CDO. This process is typically used to provide credit protection for 10% of the pool of assets held on the originator's balance sheet. The other 90% of the default risk is hedged with a highly-rated counterparty using a senior swap. This complex derivative is a way of betting on the default prospects of a pool of assets rather than on the assets themselves.

There is also a form of CDO that is highly customizable. This is called a **single-tranche CDO**. With this credit derivative, an investor is trying to earn a better spread than on comparably rated bonds by selecting a specific reference asset with customizable maturity, coupon, collateral, subordination level, and target rating. This customization feature creates open dialogue between the single-tranche CDO buyer and seller, and by default will help prevent the seller from dumping unwanted risks on the buyer without prior knowledge. One key customizable feature is the attachment point, which is the point at which default begins to be the financial responsibility of the single-tranche CDO buyer.

Rating CDOs Before the Credit Crunch

LO 34.7: Assess the rating of CDOs by rating agencies prior to the 2007 financial crisis.

The average investor has a very difficult time understanding securitized financial products, like collateralized debt obligations (CDOs). As such, they have come to rely on the stamp of approval from a third party that is thought to be independent. Rating agencies, like Moody's Investors Service, Standard & Poors, and Fitch Ratings, have profited from investors' need for supposedly independent ratings on complex financial products. From 2000 to 2007, Moody's rated nearly 45,000 mortgage-linked securitized products. Over half of this group of 45,000 received a AAA stamp of approval. By comparison, only six U.S. private sector companies had such a rating during this same time period.

Professor's Note: The Financial Crisis Inquiry Commission (FCIC), which was established by Congress, found that 73% of the pool of securitized products rated AAA by Moody's had been downgraded to junk bond status by April 2010.

Part of the push for solidly investment-grade ratings is that insurance companies, pensions, and money market funds have regulatory and internal requirements that only allow investments in investment-grade assets. Based on this level of demand and the fact that the rating agencies all had a profit motive, they were very willing to provide high ratings for many securitized products. The process would start with rating any tranche possible with a AAA rating. Then the typical next step was to repackage below-AAA rated tranches into new CDOs whereby another group emerged as AAA-rated because the default risk kept being pushed down further and further to the lowest equity tranches. This process would be repeated a few times until a substantial portion of securitized products received the coveted AAA stamp of approval.

When adjustable rates loans reached their reset periods and default rates rose well above any previously considered margin of safety, downgrades ensued en masse. By their very nature, the downgrades drove down prices, but this cycle was further compounded because once the assets were downgraded below investment-grade, every insurance company, pension fund, money market, and bank with capital constraints had to sell as well. Investors were not so much buying an income stream as they were buying a AAA-rated income stream, and once default rates began rising, the downward spiral of prices began.

In fairness to the rating agencies, it is also important to understand an alternate interpretation beyond merely a profit motive that caused the inaccurate ratings. The Financial Crisis Inquiry Commission (FCIC) found that the rating agencies were influenced by "flawed computer models, the pressure from financial firms that paid for the ratings, the relentless drive for market share, the lack of resources to do the job despite record profits, and the absence of meaningful public oversight."

The competitive pressure between these rating agencies, two of which are publicly traded, was intense. However, the competition did not translate into substantial salaries for key employees in the rating process. The result was that the best employees would leave the rating agencies and go to work for the financial firms who were actively securitizing products. The benefit to the originators was that the converted employees knew the internal ratings guidelines at the ratings agencies. For example, in order to achieve a AAA rating, a securitized product needs to have an average FICO score of 615 for all borrowers in the pool. Equipped with this knowledge, the originators could then package pools of loans with mostly 550 scores and just enough 680s to bring the average up to 615. This translated into higher default probabilities than should have naturally existed for a 615 rated borrower. There should have been more focus on the dispersion of credit scores and not just the average for the pool.

As the FCIC uncovered more details, they found many flaws in the system. The profit motive was paramount, but it drove creative packaging by the originators. The profit motive was also influenced by the competitive landscape of the industry. The profit motive will always exist in the world of high finance. What investors need to understand is that they need to dive deeply into the risk profile of any asset before adding it to their portfolios.

Key Concepts

LO 34.1

There were three key underlying flaws in the securitization process that led to the 2007–2009 financial crisis. The first is that members of the securitization supply chain were incentivized to find borrowers, sell them a loan, and package that loan for resale without retaining any default risk. This led to lax lending standards. Second, the securitized products themselves were very opaque. Neither investors nor the rating agencies that they relied upon fully understood how to evaluate their potential risks. Third, financial institutions' use of off-balance-sheet techniques to hold securitized loans further disguised the risk spectrum from investors.

LO 34.2

The traditional bank credit function can remain robust in a world of concentrated risks by utilizing credit risk transfer techniques, including bond insurance, collateralization, termination, reassignment, netting, marking to market, syndication of loan origination, or the outright sale of a loan portfolio in the secondary market.

LO 34.3

The originate-to-hold model involves originating a loan using a binary approval process and then holding the loan until maturity. In this case, the lender retains all credit risk and the loan origination process will therefore be more stringent. The originate-to-distribute model enables lenders to originate a loan based on risk-reward pricing and then outsource the risk through various channels. This provides better access to capital for less creditworthy borrowers and more diversification options for investors.

LO 34.4

Credit derivative products, such as credit default swaps, first-to-default puts, total return swaps, and asset-backed credit-linked notes are all innovations that separate default risk from the underlying security. They offer the ability to insure and transfer specific risks to both investors and insurance sellers.

LO 34.5

A collateralized debt obligation (CDO) is an asset-backed security that can branch into corporate bonds, emerging market bonds, residential mortgage-backed securities (RMBS), commercial mortgage-backed securities (CMBS), real estate investment trust (REIT) debts, bank loans, other forms of asset-backed securities backed by auto and credit card loans, and even other CDOs. A collateralized loan obligation (CLO) is a specialized form of CDO that only invests in bank loans.

LO 34.6

With a synthetic CDO, the originator retains the reference assets on their balance sheet, but they transfer credit risk, in the form of credit default swaps, to an SPV which then creates the tradable synthetic CDO. This derivative product is used to bet on the default of a pool of assets, not on the assets themselves. A single-tranche CDO is a highly customizable offshoot from synthetic CDOs. Investors can customize their maturity, coupon, collateral, subordination level, and target rating.

LO 34.7

Rating agencies were at the core of the selling process of securitized products, such as CDOs. The average investor could not understand the complex products, so they relied on the stamp of approval from the ratings agencies, who were biased by their profit motive and were often unable to fully understand the securitized products themselves.

Concept Checkers

1. Which of the following statements was not one of the flaws in the securitization process prior to the start of the credit crisis in 2007?
   A. An active originate-to-distribute model where a strong profit motive took precedence over ethical lending and underwriting.
   B. The securitized products were so opaque that investors could not evaluate the true risks of the investment.
   C. Structured investment vehicles (SIVs) were used to enhance the risk discovery process for investors and regulators.
   D. Banks held securitized assets in off-balance-sheet entities, thus further masking the true risks in the system.

2. Which of the following statements is not correct regarding total return swaps (TRS)?
   A. A TRS is designed to mirror the return on an underlying asset like a loan, stock, or even a portfolio of assets.
   B. The payer pays any depreciation in the underlying asset to the receiver.
   C. The payer pays any dividends or interest received to the receiver.
   D. The receiver is creating a synthetic long position in the underlying asset.

3. XYZ Hedge Fund wants to get exposure to a high-yield pool of commercial loans without actually investing in the loans. It wants a leverage ratio of 7.5. If the hedge fund is willing to invest $35 million in this investment, which credit derivative is best for them and what is their expected return given that the reference asset earns LIBOR plus 285 basis points, the counterparty earns LIBOR plus 150 basis points, and the required collateral earns 3.5%?
   A. Total return swap with a 13.63% return.
   B. Asset-backed credit-linked note with an 11.34% return.
   C. Total return swap with an 11.34% return.
   D. Asset-backed credit-linked note with a 13.63% return.

4. Which of the following statements describe part of the risk mitigation process for a collateralized debt obligation (CDO)?
   I. Default risk is restructured in such a way that previously lower-rated issues can be re-formulated into highly rated debt instruments.
   II. The equity tranche has no certain return and bears the highest level of default risk.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

5. Which of the following was not a cause of the misalignment between investors' and rating agencies' incentives prior to the credit crisis of 2007–2009?
   A. Profit motive of the rating agencies.
   B. Pressure from the originators of securitized products.
   C. Manipulation of the ratings process by the originators.
   D. Investors' lack of understanding of the products they were purchasing.

Concept Checker Answers

1. **C** Structured investment vehicles (SIVs) were actually used to create further layers of opaqueness. These are the off-balance-sheet entities used by banks to hold securitized products in a way that made them very difficult for investors to scrutinize.

2. **B** A total return swap transfers both credit and market risk. The payer only pays any appreciation and any dividends or interest connected with the underlying asset. The receiver is responsible to pay the payer any depreciation in the underlying asset.

3. **D** The best credit derivative for this hedge fund is an asset-backed credit-linked note. With leverage of 7.5 and an investment of $35 million, we know that the notional value of the pool of commercial loans is $262.5 million. The hedge fund will earn 3.5% on their $35 million in collateral. This translates into $1.225 million. They will also earn the 135 basis point spread on the entire $262.5 million. This translates into $3.54375 million. The hedge fund's percentage return is 13.63% [($1.225 million + $3.54375 million) / $35 million].

4. **C** The default risk in a CDO is structured through various tranches in such a way that a pool of assets that were once lower rated could be AAA rated after the securitization process. The equity tranche is the most junior tranche. Therefore, it offers the highest return potential but with no certain return. The equity tranche also bears the highest level of default risk.

5. **D** According to the findings of the congressionally formed Financial Crisis Inquiry Commission, the root causes of the misalignment were the flawed computer models at the rating agencies, the profit motive of the rating agencies, pressure from the originators, the drive for market share coming from the rating agencies, the rating agencies lack of provided (not available) resources to conduct the proper due diligence, and the absence of meaningful public oversight. A thorough post-audit of the crisis will also reveal that originators also manufactured the securitized products to specifically arrive at a AAA rating given their acquired knowledge of the rating agencies' decision flow charts.

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

An Introduction to Securitization

Topic 35

Exam Focus

Securitization is the process of selling cash-flow producing assets to a third party special purpose entity (SPE), which in turn issues securities backed by the pooled assets. Mortgage-backed securities (MBSs) securitize residential mortgages where the property serves as the collateral. For the exam, be prepared to discuss the securitization process of selling cash-flow producing assets to a special purpose vehicle (SPV) and contrast the differences between amortizing, revolving, and master trust structures. Also, be familiar with the different types of credit enhancements, and be prepared to define and calculate the various performance tools for securitized structures discussed.

Securitization Process

LO 35.1: Define securitization, describe the securitization process and explain the role of participants in the process.

Securitization is the process of transforming the illiquid assets of a financial institution or corporation into a package of asset-backed securities (ABSs) or mortgage-backed securities (MBSs). A third party uses careful packaging, credit enhancements, liquidity enhancements, and structuring to issue securities backed by the pooled cash flows (i.e., principal and interest) of the same underlying assets. Cash is transferred to the selling party, and the obligation is effectively removed from the seller's balance sheet if the sale is made without recourse. Hence, securitization represents an off-balance-sheet transaction.

A wide range of assets can be securitized (e.g., mortgages, credit card receivables, auto loans, etc.). The common feature of all ABS and MBS is that the underlying assets generate cash flows. It is important to note that the third party in the securitization process is not involved in the origination of the assets underlying the securitized product.

The two key participants in the securitization process are the originator and the issuer. The **originator** is the entity that seeks to convert its credit-sensitive assets into cash. The credit risk is then transferred away from the originator. The **issuer** is a third party who stands between the originator and the eventual investor that purchases the securities. The issuer buys the assets from the originator. The issuer must be a distinct legal entity from the originator in order for the sale of the assets to be considered a *true sale*. In a true sale, the assets are transferred off the originator's balance sheet and there is no recourse. A **special purpose vehicle** (SPV) [also sometimes referred to as a special purpose entity (SPE)] is a separate legal trust or company that is set up specifically for the purpose of securitization.

The SPV separates the underlying asset pool supporting the securitized issues from the other assets of the originator. This is an important step in the process because it ensures that the securitized assets are not affected if the originator becomes insolvent. This process of securitization provides *credit enhancement* to the newly issued securities as the third party SPV guarantees the credit quality of the issues. Thus, the investors purchasing the securitized issues are not concerned about the financial strength or creditworthiness of the originator. Investors are only concerned about the credit quality of the securitized issues and the SPV guaranteeing them. Thus, in the event that the originating financial institution becomes financially insolvent, it would not impact the SPV (except for any consideration on the first-loss piece which will be discussed later).

As stated previously, the SPV may be designated as a corporation or a trust. For tax purposes, SPVs are often incorporated in offshore locations such as the Cayman Islands, Dublin, or the Netherlands, which are regions that have SPV-friendly legislation. If the SPV is set up as a *corporation*, the originator sells the assets to the SPV in exchange for cash. The SPV, in turn, issues claims directly against the assets of the SPV. In European countries, accounting regulations allow SPVs to be structured as corporations. However, this method may not distance the originator from the assets enough for accounting purposes in the United States. Therefore, in the United States, the SPV *trust* is the most common structure.

The most common application for an SPV is to set up cash flow securitization where the originator sells the assets to the SPV who funds the purchase of the assets by issuing notes to investors. However, SPVs are also used to convert the currency of underlying assets through currency swaps, issue credit-linked notes (CLNs), and transfer illiquid assets into liquid assets (e.g., accounts receivables from equipment leases).

The **structuring agent** is the *de facto* advisor for the securitization issue. This agent is largely responsible for the security design (e.g., maturity, desired credit rating, credit enhancement, etc.) and forecasting the interest and principal cash flows. The structuring agent may also be the **sponsor** as the two roles have natural overlap.

In the event of a default, a **trustee** is charged with the fiduciary responsibility to safeguard the interests of the investors who purchase the securitized products. The trustee will monitor the assets based on pre-specified conditions of the asset pool such as minimum credit quality and delinquency ratios.

An insurance company referred to as the **financial guarantor** is sometimes used to wrap the deal by providing a guarantee of financial support in the event the SPV defaults. Financial guarantors are more common in a master trust arrangement, which we will cover later in this topic.

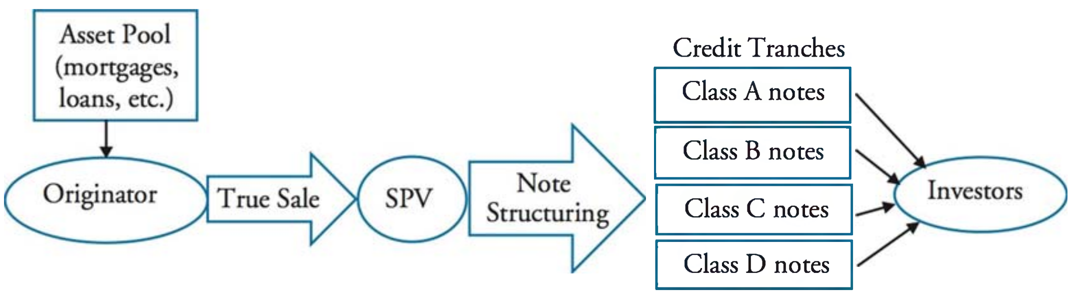
The **custodian** was initially responsible for safeguarding the physical securities. This role has evolved to also include the collection and distribution of the cash flows of assets like equities and bonds.

Credit rating agencies such as Moody's, Standard & Poor's, or Fitch also play an important role in the securitization process. The rating agencies provide formal credit ratings for each securitization. The rating agencies quantify the corporate credit quality of the originator. In addition, they provide analysis on competitors, the industry, regulatory issues, the legal

structure of the SPV, and cash flows. If the credit rating is too low, the securitization deal may be restructured by the structuring agent to offer additional credit enhancements.

Figure 1 illustrates how the SPV purchases assets from an originator. The purchase of these assets is funded by issuing notes and selling them to investors. The structure of the issues is often customized to meet the credit quality needs of the investors via tranches. As mentioned, the process of securitization allows the originator to remove credit risk and assets from their balance sheet.

Figure 1: Securitization Process



Cash Waterfall Process

LO 35.2: Explain the terms over-collateralization, first-loss piece, equity piece, and cash waterfall within the securitization process.

The securitization process issues notes that are structured to meet specific needs of investors by pooling the assets into different classes referred to as **tranches**. The quality of credit on the lowest rated assets can be enhanced by a method known as **overcollateralization**. The lowest class of notes is often overcollateralized by issuing notes with a principal value that is less than the principal value of the original underlying assets purchased from the originator. For example, assume a mortgage pool was securitized based on 100 mortgages, but the originator included 101 mortgages in the pool. This issue is overcollateralized by one mortgage. Thus, investors in the mortgage pool can absorb one default before suffering any economic losses.

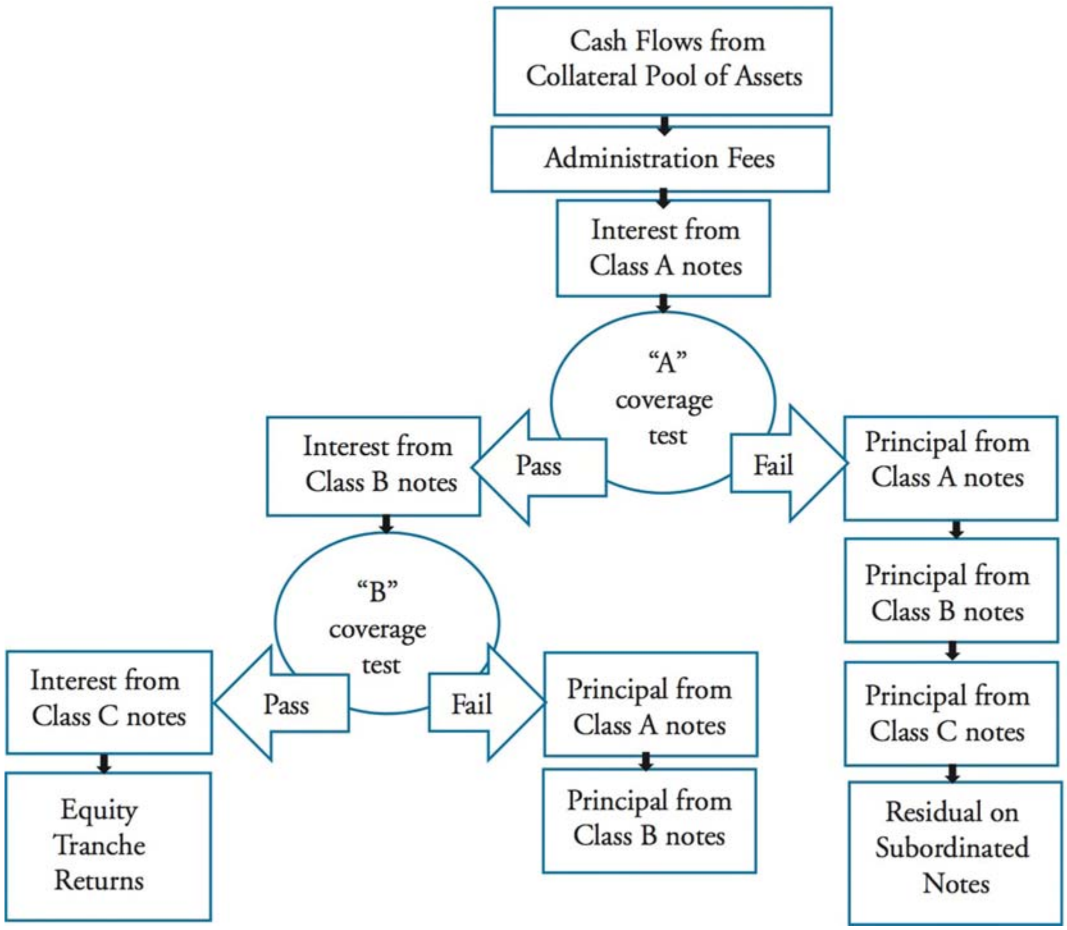
The **first-loss piece** is the class of assets with the lowest credit quality. This is the most junior level where losses are first absorbed in the event of a default. The originator often maintains ownership of the first-loss piece. Because the originator still has ownership of this first-loss piece, it is also sometimes referred to as the **equity piece** (or the **equity tranche**). The first-loss piece or equity piece is often non-rated and absorbs initial losses.

The **cash waterfall** process of securitization refers to the order in which payments from the asset pool are paid to investors. Senior tranches are paid prior to making payments to junior tranches. A third party is hired to run "tests" in order to ensure cash flows are sufficient to pay all outstanding liabilities.

Figure 2 illustrates how cash flows are allocated to the different tranches in the cash waterfall process. If the first coverage test passes, then interest payments are made to

subordinate tranche levels. However, if a coverage test fails, then the principal of the notes will begin to be paid off starting with the most senior tranche.

Figure 2: Cash Flow Waterfall



SPV Structures

LO 35.3: Analyze the differences in the mechanics of issuing securitized products using a trust versus a special purpose vehicle (SPV) and distinguish between the three main SPV structures: amortizing, revolving, and master trust.

The three main special purpose vehicle (SPV) structures used in the securitization process are amortizing, revolving, and master trust. The master trust is a special type of structure that is used for frequent issuers. The difference in how payments are received over the asset-backed security's life determines whether the ABS is better suited to the amortizing or revolving structure.

In an **amortizing structure**, principal and interest payments are made on an amortizing schedule to investors over the life of the product. Because payments are made as coupons are received, this type of structure is referred to as a *pass-through structure*. Amortizing structures are very common with the securitization of products that have amortization schedules such as residential mortgages, commercial mortgages, and consumer loans. Amortizing structures

are valued based on the expected maturity and the *weighted-average life (WAL)* of the asset. The WAL is the time-weighted period that the underlying assets are outstanding. Because borrowers of mortgages and consumer loans often have the option to pay off the loans early, the WAL must include pre-payment assumptions to estimate the rate at which principal is repaid over the life of the loans.

Revolving structures are used with products that are paid back on a revolving basis. Thus, under the revolving structure, principal payments of the assets are paid in large lump sums rather than a pre-specified amortization schedule. Credit card debt and auto loans are examples of products that are securitized using a revolving structure due to their short time horizon and high rate of pre-payments. Under a revolving structure, payments are not simply passed through. Rather, principal payments are often used to purchase new receivables with criteria similar to assets already in the pool. Investors are repaid by principal payments through controlled amortization or in single lump sum payments referred to as soft bullet payments.

Professor's Note: The term revolving structure is similar in nature to a revolving loan issued by a commercial bank to a corporation. Under the terms of a revolving loan, the corporation has a line of credit and is required to pay down that line of credit to zero every year. Thus, the loan does not amortize to reduce the balance, rather the balance is reduced in large lump sum payments.

A **master trust structure** allows an SPV to make frequent issues or multiple securitizations. The originator transfers assets to the master trust SPV who in turn issues new notes from this asset pool. Master trusts are often used in the securitization of mortgages and credit card debt.

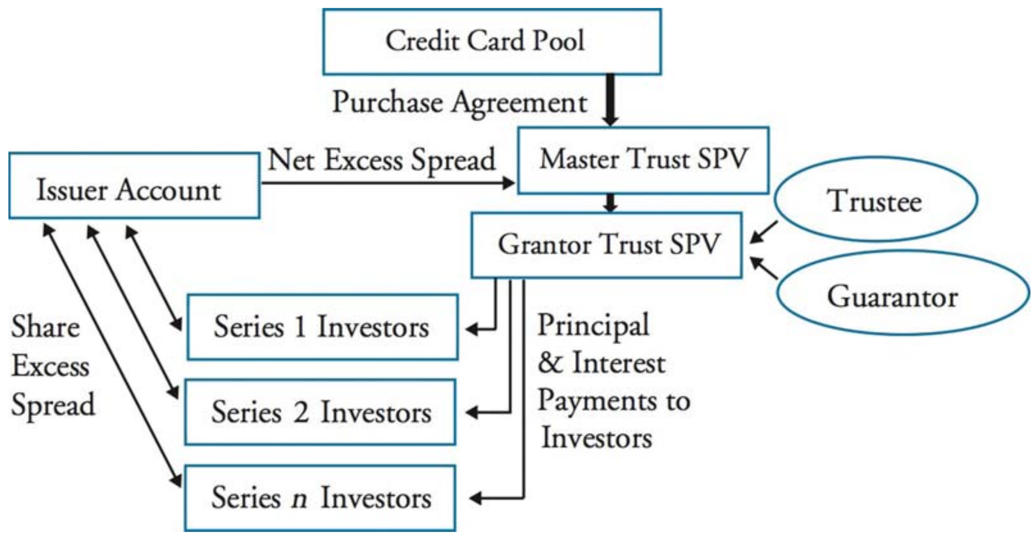
Figure 3 illustrates the securitization process for credit card asset-backed securities (ABS) using the SPV master trust structure. The pool of credit card receivables is changing over time. However, the master trust structure enables the SPV to issue multiple ABS through the single trust. Investors from different series receive payments from the entire pool of credit card ABS.

Excess spread is created from the high yield credit card debt less the cost of issuing the ABS. The excess spread is the difference between the cash inflows from the underlying assets and the cash outflows in the form of interest payments on the ABS issues. After administration expenses are covered, any remaining excess spread is held in a reserve account to protect against future losses. If there are no future losses, the remaining excess spread is returned to the originator.

As illustrated by Figure 3, under a trust arrangement two distinct SPVs are created. The additional entity is created to further distance the originator from the issuer and the underlying assets. A common arrangement will involve a master trust, or special purpose vehicle (SPV), and a grantor trust. In contrast to the previous approach (i.e., corporation), the assets do not serve directly as collateral. Under this arrangement, the originator sells the assets to the master trust (SPV 1) for cash, but the master trust in turn deposits the assets in the grantor trust (SPV 2). The master trust receives a beneficial interest in the grantor trust, which represents the same economic position as if only one SPV was employed. Now the claims of the securitized products are backed by the beneficial claim on the master trust rather than on the assets themselves.

Credit card debt is not collateralized and typically suffers from a low rate of recovery in the event of default. Therefore, a **financial guarantor** is used as a credit enhancement. If there are payment defaults for a series, the excess spread is shared to cover the losses. The ability of SPV master trust structures to sell multiple issues to investors that share excess spreads over these multiple series makes this structure very different from the amortizing and revolving structures.

Figure 3: Master Trust Structure



Securitization Benefits

LO 35.4: Explain the reasons for and the benefits of undertaking securitization.

Benefits to Financial Institutions

The three main reasons for a financial institution to use securitization are for funding assets, balance sheet management, and risk management. Typically a financial institution specializes in financing specific assets such as residential mortgages, automobile loans, commercial loans, or credit card debt. Securitization of these assets provides funding for the financial institution that helps support growth, diversifies the funding mix, and reduces maturity mismatches. The diversification of the funding mix reduces risk and the cost of funding. The originator separates the assets from its balance sheet by going through a third party (i.e., the SPV).

Asset-backed securities (ABS) issued by a SPV often have higher credit ratings than the original notes issued by the originator. If the SPV has a higher credit rating, then the originating institution benefits by lowering the cost of issuing debt when going through the SPV. ABS markets are not as liquid as bond markets, but the lower credit ratings of SPVs typically make them a more cost effective funding option. Thus, the cost savings from securitization creates a cash surplus for the originator. In addition, financial institutions often use short-term liabilities (such as savings and checking account balances) to fund long-term assets (such as residential mortgages). Securitization allows notes to be issued

by the SPV that match the time horizon of the underlying asset. At the same time, the originator is able to remove the risk of mismatched durations on the balance sheet.

Another reason financial institutions securitize assets is to manage the capital on their balance sheets. The Basel I Accord set capital requirements for banks based on the riskiness of the assets. Basel I capital requirements provided a big incentive for banks to securitize assets in order to gain regulatory capital relief. SPVs are not categorized as banks, so they are not subject to the same capital requirements as banks. For example, regulators may require banks to hold capital of 8% of the bank's total asset value. An originating bank is able to reduce capital requirements by selling assets to an SPV. As mentioned earlier, originators often keep a portion of the capital exposure by retaining the first-loss piece. Therefore, the capital requirements from the securitization are significantly reduced, but not completely eliminated. By reducing capital requirements, securitization is a form of raising capital. Banks need to issue less preferred stock and other forms of equity when they securitize assets. The reduction of capital also increases the return on equity (ROE) which is a key ratio for investors.

In addition to providing regulatory relief, securitization provides additional risk management benefits in the form of removing non-performing assets from the balance sheet. Securitization removes the credit risk as well as the negative sentiment associated with non-performing assets. Furthermore, the originator may receive surplus profit from the SPV in the event these non-performing assets start returning cash flows in the future.

Benefits to Investors

Securitization also provides benefits for investors. As a result of securitizations, investors have access to new liquid assets that were previously not available to them. This allows investors to create different risk-reward profiles and diversify into new sectors. Securitized notes often provide higher risk-reward incentives than corporate bonds with the same credit rating. The improved performance results from the originator maintaining the equity tranche. In addition, holding a securitized asset diversifies the risk exposure because the securitized asset is purchased from an SPV with a pool of assets as opposed to a corporate bond from one entity. Securitization broadens the market for buyers and sellers through diversification and customization of new liquid products. The increased liquidity reduces transaction costs, which benefits both borrowers and investors.

Credit Enhancements

LO 35.5: Describe and assess the various types of credit enhancements.

Credit enhancements play an important role in the securitization process by improving the credit rating for the asset-backed security (ABS) or mortgage-backed security (MBS) tranches. The benefits of improved credit quality are even greater for the lowest-rated assets. The different types of credit enhancements used in securitization include: overcollateralization, pool insurance, subordinating note classes, margin step-up, and excess spread.

The first two types of credit enhancements are designed to increase the ability of collateral to absorb losses associated with defaults in the underlying asset pool. The lowest class of notes often exhibit **overcollateralization** where the principal value of the notes issued are valued less than the principal value of the original underlying assets. The additional collateral of the ABS issues absorbs initial losses with no impact to investors. The credit rating can also be enhanced by offering **pool insurance**. A composite insurance company provides pool insurance on the ABS issues that covers the loss of principal in the collateral pool in the event an SPV defaults.

Other types of credit enhancements are designed to control the cash flows from the collateral pool. **Subordinating note classes** of a collateral pool into different tranches is another type of credit enhancement. Junior or class B notes are subordinate to more senior class A notes. Therefore, investors in class B do not receive payments of principal until the class A notes are fully redeemed or until rating agency requirements are met. The collateral pool is required to pass certain performance tests over a period of time before making principal payments on subordinate notes.

Two other cash flow related credit enhancements are margin step-up and excess spread. ABS issues sometimes use a **margin step-up** that increases the coupon structure after a call date. The issuer has the option to redeem the notes after this call date. The margin step-up provides investors with an extra incentive to invest in the issues. However, the issuer may refinance if the increased coupons are greater than market rates.

The **excess spread** is the difference between the cash inflows from the underlying assets and the cash outflows in the form of interest payments on the ABS issues. The securitization is structured such that the liability side of the SPV (issued notes) has a lower cost than the asset side of the SPV (receivables from mortgages, loans, or credit card debt). After administration expenses are covered, any remaining excess spread is held in a reserve account to protect against future losses. If there are no future losses, the remaining excess spread is returned to the originator.

Performance Measures for Securitized Structures

LO 35.6: Explain the various performance analysis tools for securitized structures and identify the asset classes they are most applicable to.

There are a number of performance tools designed to analyze the collateral pool of asset-backed security (ABS) and mortgage-backed security (MBS) products. MBS products were first created to provide cheaper financing for residential homes by issuing pass-through securities. Investors benefited from a new liquid asset class and lenders benefited by removing interest rate risk off the balance sheet. In addition, MBS were backed by a government-sponsored entity with "Ginnie Mae" issues. Auto loans and credit card ABS products also became more popular with investors during the low interest rate environment of 2002–2007. Investor demand grew for ABSs because they provided diversification benefits and offered higher returns than the corporate bond market.

The portfolio performance of ABS and MBS products is largely dependent on the ability of individuals to pay off their obligations in the form of consumer debt and mortgages. Performance measures serve as trigger methods to accelerate amortization. ABS structures

also have reserve accounts to protect against losses resulting from interest shortfalls. A key difference between the collateralized debt obligations (CDOs) and ABS structures is the number of underlying loans. A CDO portfolio typically consists of less than 200 loans, while ABS or MBS structures often have much greater diversity with thousands of obligors.

Auto Loan Performance Tools

There are specific performance measures that are used for different asset class types. *Auto loans* have features that are very favorable for investors in this ABS product. Auto loans are collateralized with assets that are highly liquid in the event of default. In addition, most loans have a short three to five year horizon. Thus, there is virtually no prepayment risk and losses are relatively low compared to other ABS.

A good measure of performance for auto loan ABS is the **loss curve**. The loss curve shows the expected cumulative loss for the life of the collateral pool. The expected losses based on the loss curve are compared to actual losses. Originators of prime loans typically have evenly distributed losses. Subprime or non-prime loan originators have higher initial losses resulting in a steeper loss curve. Losses for all types of loans typically decline in later years of the curve.

Another important performance tool for the auto loan ABS is the **absolute prepayment speed** (APS), which indicates the expected maturity of the issued ABS. The APS measures prepayment by comparing the actual period payments as a percentage of the total collateral pool balance. The APS is an important measure that is used to determine the value of the implicit call option of the ABS issue at any time.

Credit Card Performance Tools

Another type of ABS product is collateralized by pools of *credit card debt*. The fact that credit cards have no predetermined term for outstanding balances differentiates this class from other ABS products. Despite having no predetermined term, most credit card debt is repaid within six months. The repayment speed of a credit card ABS is controlled by scheduled amortization or a revolving period under a master trust framework. Recall that the master trust allows multiple issues and principal collections to be used to purchase new receivables.

Three important performance tools for credit card receivables of ABS are the delinquency ratio, default ratio, and monthly payment rate (MPR). These three ratios serve as triggers to signal early amortization of the receivable pool. The delinquency ratio and default ratio measure the credit loss on credit card receivables pools. An early indication of the overall quality of the credit card ABS collateral pool is the delinquency ratio. The **delinquency ratio** is computed by dividing the value of credit card receivables that are 90 days past due by the total value of the credit card receivables pool. The **default ratio** is calculated by dividing the amount of written off credit card receivables by the total credit card receivables pool. The **monthly payment rate** (MPR) is calculated as the percentage of monthly principal and interest payments divided by the total credit card receivables pool. Rating agencies require every non-amortizing ABS (such as credit cards) to set a minimum MPR as a trigger for early amortization.

LO 35.7: Define and calculate the delinquency ratio, default ratio, monthly payment rate (MPR), debt service coverage ratio (DSCR), the weighted average coupon (WAC), the weighted average maturity (WAM), and the weighted average life (WAL) for relevant securitized structures.

As described previously, the delinquency ratio, default ratio, and monthly payment rate (MPR) serve as triggers to signal early amortization of the receivables pool for an ABS.

Example: Delinquency ratio, default ratio, monthly payment rate

Suppose an ABS has a total outstanding balance of credit card receivables of $57,800,000. $49,900,000 of the total receivables are current, $5,750,000 of the receivables are over 30 days past due, $1,270,000 of the receivables are over 60 days past due, and $880,000 are over 90 days past due. In addition, $1,100,000 of receivables were written off. Total monthly principal and interest payments per month are $1,560,000. **Calculate** the delinquency ratio, default ratio, and monthly payment rate for this ABS.

Answer:

The delinquency ratio 1.522%, computed by dividing the value of credit card receivables over 90 days past due by the total credit card receivables pool ($880,000 / $57,800,000).

The default ratio is 1.903%, calculated by dividing the amount of written off credit card receivables by the total credit card receivables pool ($1,100,000 / $57,800,000).

The monthly payment rate (MPR) is 2.699%, calculated as the percentage of monthly principal and interest payments divided by the total credit card receivables pool ($1,560,000 / $57,800,000).

MBS Performance Tools

The debt service coverage ratio (DSCR), weighted average coupon (WAC), weighted average maturity (WAM), and weighted average life (WAL) are performance tools used to analyze MBS. The **debt service coverage ratio** (DSCR) is calculated by dividing net operating income (NOI) by the total amount of debt payments. Net operating income is the income or cash flows that are left over after all of the operating expenses have been paid. The DSCR is a performance tool that measures the ability of a borrower to repay the outstanding debt associated with commercial mortgages. A DSCR less than one indicates that the underlying asset pool of commercial mortgages do not generate sufficient cash flows to cover the total debt payment. Total debt service refers to all costs related to servicing a company's debt. This often includes interest payments, principal payments, and other obligations. As investors' confidence levels in the securitization increase, the required DSCR decreases, and vice versa. For residential mortgages, this ratio is typically between 2.5 and 3.0. However, higher DSCR are needed with more risky receivables where the value of the receivables is highly discounted in the event of a default.

Example: Debt service coverage ratio

Suppose an MBS has net operating income from commercial mortgaged properties equal to \$89,572,500. The total debt payments for notes issued against these mortgages is equal to \$87,958,000. **Calculate** the debt service coverage ratio (DSCR).

Answer:

The DSCR is equal to 1.02, calculated as \$89,572,500 / \$87,958,000. A DSCR greater than one implies that there is sufficient cash flows generated from the underlying mortgage pool to meet debt payments. However, this is a very low DSCR for mortgages.

The **weighted average coupon** (WAC) is calculated by multiplying the mortgage rate for each pool of loans by its loan balance and then dividing by the total outstanding loan balance for all pools. Thus, it measures the weighted coupon of the entire mortgage pool. The WAC is compared to the net coupon payable to investors as an indication of the mortgage pool's ability to pay over the outstanding life of the MBS.

Example: Weighted average coupon

Suppose an MBS is composed of three different pools of mortgages: \$6 million of mortgages that yield 7.8%, \$10 million of mortgages that yield 6.0%, and \$4 million of mortgages that yield 5%. **Calculate** the weighted average coupon (WAC).

Answer:

The WAC is calculated as follows:

$$\begin{aligned} \text{WAC} &= [0.078(6 \text{ million}) + 0.06(10 \text{ million}) + 0.05(4 \text{ million})] / (6 \text{ million} + 10 \text{ million} \\ &\quad + 4 \text{ million}) \\ &= (0.468 \text{ million} + 0.6 \text{ million} + 0.2 \text{ million}) / 20 \text{ million} \\ &= 1.268 \text{ million} / 20 \text{ million} \\ &= 0.0634 \text{ or } 6.34\% \end{aligned}$$

If notes issued by the SPV are for 5.5%, for example, then an excess spread will be generated if there are no defaults on the original mortgages.

The **weighted average maturity** (WAM) is the weighted average months remaining to maturity for the pool of mortgages in the MBS. To calculate the WAM, the weight of each MBS pool is multiplied by the time until maturity of each MBS pool, and then all the values are added together. (Note that the weight is determined by taking the total value of the pool for one maturity and dividing that by the total value of all loans.)

The volatility of an MBS is directly related to the length of maturity of the underlying securities. The WAM is calculated based on stated maturity dates or reset dates. A WAM calculated based on stated maturity dates includes the liquidity risk of all mortgage securities in the portfolio by using the actual maturity date. A WAM calculated based on reset dates captures the effect of prepayments on the maturity of the loans.

Example: Weighted average maturity

Suppose an MBS is composed of three different pools of mortgages: \$6 million of mortgages that have a maturity of 180 days, \$10 million of mortgages that have a maturity of 360 days, and \$4 million of mortgages that have a maturity of 90 days. **Calculate** the weighted average maturity (WAM).

Answer:

The WAM is calculated as follows:

WAC = [180(6 million) + 360(10 million) + 90(4 million)] / (6 million + 10 million + 4 million)

= (1,080 million + 3,600 million + 360 million) / 20 million

= 5,040 million / 20 million

= 252 days

The **weighted average life** (WAL) of the mortgage notes issued is calculated by summing the time to maturity multiplied by a pool factor using the following formula:

$$\text{WAL} = \sum (\text{a} / 365) \times \text{PF(t)}$$

Figure 4 illustrates how WAL is calculated for an MBS with an initial outstanding balance for the entire pool of \$89,530,000. The pool factor, *PF(t)*, is the outstanding notional value adjusted by the repayment weighting. The actual days, *a*, until the next payment are stated in column B. This amount in column B is then divided by 365 in column F to calculate the time to maturity. The amount in column F is multiplied by column C to compute each individual note's weighted life and this is recorded in column G. WAL is then determined as the summation of column G.

Figure 4: Calculation of WAL

A	B	C	D	E	F	G
Payment Date	*Actual Days (a)*	*PF(t)*	*Paid Principal*	*Outstanding Balance (000s)*	*a / 365*	*(a/ 365) × PF(t)*
11/21/2008	66	1.00		89,530	0.1808	0.1808
1/26/2009	90	0.94	5,059	84,471	0.2466	0.2318
4/26/2009	91	0.89	4,941	79,530	0.2493	0.2219
7/26/2009	91	0.83	4,824	74,706	0.2493	0.2069
10/25/2009	91	0.75	4,706	70,000	0.2493	0.1870
1/24/2010	91	0.73	4,588	65,412	0.2493	0.1820
4/25/2010	91	0.68	4,471	60,941	0.2493	0.1695
7/25/2010	91	0.63	4,353	56,588	0.2493	0.1571
10/24/2010	92	0.58	4,235	52,353	0.2521	0.1462
1/24/2011	90	0.54	4,118	48,235	0.2466	0.1332
4/24/2011	91	0.49	4,000	44,235	0.2493	0.1222
7/24/2011	92	0.45	3,882	40,353	0.2521	0.1134
10/24/2011	92	0.41	3,765	36,588	0.2521	0.1033
1/24/2012	91	0.37	3,647	32,941	0.2493	0.0922
4/24/2012	91	0.33	3,529	29,412	0.2493	0.0823
7/24/2012	92	0.29	3,412	26,000	0.2521	0.0731
10/24/2012	92	0.25	3,294	22,706	0.2521	0.0630
1/24/2013	90	0.22	3,176	19,530	0.2466	0.0542
4/24/2013	91	0.18	3,058	16,472	0.2493	0.0449
7/24/2013		0	16,472	0	0	0
					WAL =	**2.565**

Prepayment Forecasting

LO 35.8: Explain the prepayment forecasting methodologies and calculate the constant prepayment rate (CPR) and the Public Securities Association (PSA) rate.

Common methodologies used to estimate prepayments for an MBS or ABS collateralized by mortgages or student loans are the **constant prepayment rate** (CPR) and the **Public Securities Association** (PSA) method. Assumptions regarding the rate of prepayment are required to estimate the cash flows for an MBS. Prepayments will reduce the yield of an MBS, assuming principal payments remain unchanged.

The CPR is calculated as: $\text{CPR} = 1 - (1\text{–SMM})^{12}$. The **single monthly mortality** (SMM) is the single-month proportional prepayment. Factors that influence the CPR are market environment, characteristics of the underlying mortgage pool, and the outstanding balance of the pool.

Example: Constant prepayment rate

Suppose an ABS has an SMM of 1.5%. This implies that the approximate prepayment for the month is equal to 1.5% of the remaining mortgage balance for the month less the scheduled principal repayment. **Calculate** the CPR for this MBS.

Answer:

The CPR for this MBS equals 16.59%, calculated as: CPR = $1 - (1 - 0.015)^{12} = 0.1659$.

The PSA typically assumes that prepayments will increase as a pool approaches maturity. The MBS pool of mortgages has a 100% PSA if its CPR begins at 0 and increases 0.2% each month for the first 30 months. A graph of the CPR for an ABS as it approaches maturity is illustrated in Figure 5.

Note that the middle line in Figure 5 represents 100% PSA where the prepayments are assumed to start at 0 and increase 0.2% each month up until month 30. After 30 months, the 100% PSA is assumed to be at a constant 6% (calculated as 0.2 times 30 months) until maturity. Other prepayment scenarios are then calculated as a percentage of this 100% base case. Thus, a 50% PSA assumes 50% of the initial increase for the first 30 months. In Figure 5, the bottom line represents the 50% PSA scenario where prepayments are assumed to increase 0.1% each month for the first 30 months, before reaching a constant prepayment rate of 3%. Similarly, the top line represents the 150% PSA scenario where prepayments are assumed to increase 0.3% each month for the first 30 months, before reaching a constant prepayment rate of 9%.

Figure 5: Different Prepayment Scenarios

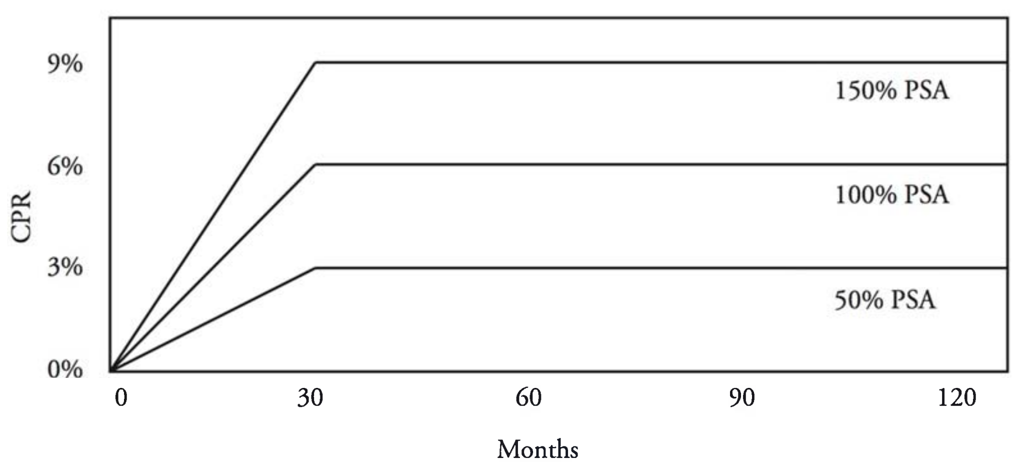


Figure 6 summarizes performance tools discussed in this topic based on the type of ABS or MBS.

Figure 6: ABS and MBS Performance Tools

Performance Analysis Tools	*Asset Type*	*Calculation*
loss curves	auto loans	expected cumulative losses
absolute prepayment speed (APS)	auto loans	prepayments / pool balance
delinquency ratio	credit cards	past due receivables / pool balance
default ratio	credit cards	defaults / pool balance
monthly payment rate (MPR)	credit cards	receivables collected / pool balance
debt service coverage ratio (DSCR)	commercial mortgages	NOI / debt payments
weighted average coupon (WAC)	mortgages	weighted pool coupon payments
weighted average maturity (WAM)	mortgages	weighted pool maturity
weighted average life (WAL)	mortgages	$\sum (a / 365) \times PF(t)$
single monthly mortality (SMM)	mortgages, home-equity, student loans	prepayment / pool balance
constant prepayment rate (CPR)	mortgages, home-equity, student loans	$1 - (1\text{-SMM})^{12}$
Public Securities Association (PSA)	mortgages, home-equity, student loans	[CPR / (0.2)(months)] × 100

Securitization after the Credit Crunch

LO 35.9: Explain the decline in demand in the new-issue securitized finance products following the 2007 financial crisis.

The financial crisis of 2007–2009 was a direct result of the subprime mortgage problems that led to an asset-backed commercial paper standstill. The liquidity crisis faced by large financial institutions led to a worldwide recession. U.S. mortgage defaults quickly rippled worldwide through the globally integrated banking system and global investments in structured credit products backed by U.S. mortgages. Collateralized debt obligations (CDOs) and other ABS were key contributors in poor lending decisions in the U.S. mortgage market.

Key factors that led to the loss in market confidence and the 2007–2009 financial crisis were the impact of the credit crunch, shadow banking system, leverage, lack of transparency, credit rating agencies' practices, accounting rules, and liquidity. These factors led to negative sentiment among investors and a sharp decline in the new-issue securitization market.

The widespread use of securitization to remove assets from the balance sheet of financial institutions eventually led to the **credit crunch**. Subprime lenders made excessive amounts of low quality loans and then removed these loans from their balance sheets through ABS. Investors were overconfident in buying these ABS and unaware of the risks in this market.

The securitization structure is designed to break the link between loan originators and borrowers. Loans are carefully grouped and packaged into tranches and sold to investors who have no knowledge of the credit quality of the original borrowers. A **shadow banking system** was created where entities are not bound by the same regulatory requirements of normal banks. These entities in the shadow banking system were referred to as special investment vehicles (SIVs). SIVs funded loans through commercial paper and did not rely on the central bank's discount window as a backup source of funding. This worked until the shadow bank was no longer able to find investors in this market. The inability to refinance the securitized products led to a liquidity crisis.

SIVs were **highly leveraged** just prior to the market collapse in 2007. Leverage ratios of 1:15 were common at this time. Some SIVs had leverage ratios as high as 1:50 as they increased their borrowing in an attempt to compensate for the shrinking credit spreads during the bull market. The use of leverage was even more problematic for CDOs that invested in other CDOs.

The **lack of transparency** resulted in increasingly complex products. Valuing products with no transparency is extremely difficult. As the credit crisis progressed, the wide variety of ABS tranches that existed in the market became very difficult to mark-to-market due to the widening of credit spreads for tranches and the changing correlation risk for ABS portfolios. To complicate matters even further, the changes in correlations had different impacts for different seniority levels of tranches.

Credit rating agencies (CRAs) were overly optimistic in their ratings due to poor credit quality models and a lack of understanding of the degree of correlation risk for ABSs. High ratings were justified for lenders on the assumption that the residential real estate market would continue to increase in value. The models used by rating agencies did not correctly incorporate the impact of correlations or sharp declines in real estate values.

Investors viewed securitized products as AAA rated with high liquidity. Unfortunately, the **liquidity** of ABS was overestimated. As the first losses were realized in the subprime lending market, SPVs needed to unwind or sell off investments in securitized paper. The SPVs mispriced the securities initially by failing to include a liquidity premium.

The impact of the liquidity crisis was even greater due to mark-to-market **accounting rules**. As investments were marked-to-market, it created a downward spiral effect in asset prices of securitized products. In the flight-to-quality environment of a liquidity crisis, financial institutions were required to mark down asset values based on highly stressed prices in the secondary market. To complicate things further, securitized products were more negatively impacted than plain vanilla commercial paper, which is characteristic of markets where participants are attempting to shed risky assets for safer ones.

Key Concepts

LO 35.1

Securitization is the process of issuing securities against an asset pool. The proceeds of the security sale collateralize the purchase of the assets from the originator, thereby removing the liability and involvement of the originator. A special purpose vehicle (SPV) is used to separate the assets from the originator and customize the products for investors.

LO 35.2

A common credit enhancement of securitized assets is overcollateralization where the principal value of the notes issued by the SPV are valued less than the principal value of the original underlying assets. The first-loss piece or equity piece absorbs initial losses. This non-rated junior tranche is often held by the originator.

LO 35.3

The master trust is a special type of structure that is used for frequent issuers. The difference in how payments are received from the underlying collateral over the asset-backed security's life determines whether the ABS is better suited to the amortizing or revolving structure.

LO 35.4

Financial institutions benefit from securitization by funding assets, balance sheet management, and risk management. Securitization benefits investors by providing access to liquid assets that were previously not available to them.

LO 35.5

Credit enhancements such as overcollateralization, pool insurance, subordinating note classes, margin step-up, and excess spread enable originators to lower costs while providing investors customized products that meet their needs.

LO 35.6

The portfolio performance of ABS and MBS products is largely dependent on the ability of individuals to pay off their obligations in the form of consumer debt and mortgages. Performance measures serve as trigger methods to accelerate amortization.

The loss curve shows the expected cumulative loss for the life of the collateral pool. The absolute prepayment speed (APS) measures prepayment by comparing the actual period payments as a percentage of the total collateral pool balance.

LO 35.7

The delinquency ratio is computed by dividing the value of credit card receivables more than 90 days past due by the total credit card receivables pool. The default ratio is calculated by dividing the amount of written off credit card receivables by the total credit card receivables pool. The monthly payment rate (MPR) is calculated as the percentage of monthly principal and interest payments divided by the total credit card receivables pool.

The debt service coverage ratio (DSCR) is calculated by dividing net operating income (NOI) by the total amount of debt payments. The weighted average coupon (WAC) is calculated by multiplying the mortgage rate for each pool of loans by its loan balance and then dividing by the total outstanding loan balance for all pools. The weighted average maturity (WAM) is the weighted average months remaining to maturity for the pool of mortgages in the MBS. The weighted average life (WAL) of the mortgage notes issued is calculated by summing the time to maturity multiplied by a pool factor, which is the outstanding notional value adjusted by the repayment weighting.

LO 35.8

Common methodologies used to estimate prepayments for securitized products collateralized by mortgages or student loans are the constant prepayment rate (CPR) and the Public Securities Association (PSA) method.

The CPR is calculated as: $CPR = 1 - (1\text{-}SMM)^{12}$

The PSA typically assumes that prepayments will increase as a pool approaches maturity. The MBS pool of mortgages has a 100% PSA if its CPR begins at 0 and increases 0.2% each month for the first 30 months.

LO 35.9

Key factors that led to the loss in market confidence and the financial crisis of 2007–2009 include: the impact of the credit crunch, shadow banking system, leverage, lack of transparency, credit rating agencies' practices, accounting rules, and liquidity.

Concept Checkers

1. A major benefit of securitization for a financial institution is the ability to remove assets from the balance sheet, which lowers risk and the required regulatory capital. While a large portion of the risk is removed from the balance sheet the originating financial institution often maintains a portion of the risk. Which of the following terms best identify the risk that is maintained by the originator?
   A. Correlation.
   B. Excess spread.
   C. First-loss piece.
   D. Guarantor of collateral value.

2. Securitized products are often customized to meet the needs of the investor as well as the originator. What type of asset-backed securities (ABSs) typically uses a revolving structure?
   A. Residential mortgage.
   B. Credit card debt.
   C. Commercial mortgage.
   D. Commercial paper.

3. Which of the following statements regarding credit enhancements in the process of structuring a securitization through a special purpose vehicle (SPV) is correct?
   A. The securitization process is structured such that the asset side of the SPV has a lower cost than the liability side of the SPV.
   B. Credit enhancements are typically only associated with mortgage-backed securities (MBS) and are not used in other types of asset-backed securities (ABS).
   C. The most senior class of notes is often overcollateralized in order to reduce the risk of the asset-backed security (ABS).
   D. A margin step-up is sometimes used by an asset-backed securities (ABS) where the coupon structure increases after a call date.

4. Which of the following measures are most likely to be used by a securitized product backed by student loans?
   A. Single monthly mortality (SMM), constant prepayment rate (CPR), and Public Securities Association (PSA).
   B. Loss curves and absolute prepayment speed (APS).
   C. Weighted average life (WAL), weighted average maturity (WAM), and weighted average coupon (WAC).
   D. Debt service coverage ratio (DSCR) and monthly payment rate (MPR).

5. Assume an MBS is composed of the following four different pools of mortgages:
   - \$2 million of mortgages that have a maturity of 90 days.
   - \$3 million of mortgages that have a maturity of 180 days.
   - \$5 million of mortgages that have a maturity of 270 days.
   - \$10 million of mortgages that have a maturity of 360 days.

   What is the weighted average maturity (WAM) of these mortgage pools?
   A. 167 days.
   B. 225 days.
   C. 252 days.
   D. 284 days.

Concept Checker Answers

1. **C** The originator often maintains ownership of the first-loss piece, which is the class of assets with the lowest credit quality and is the most junior level where losses are first absorbed in the event of a default.

2. **B** Revolving structures are used with products that are paid back on a revolving basis, such as credit card debt or auto loans. Credit card debt does not have a pre-specified amortization schedule; therefore the principal paid back to investors is in large lump sums rather than amortizing schedules.

3. **D** ABS issues may use a margin step-up that increases the coupon structure after a call date. Credit enhancements play an important role in the securitization process for both the asset-backed security (ABS) and mortgage-backed security (MBS) issues. The liability side of the SPV has a lower cost than the asset side of the SPV to create an excess spread prior to administration costs. The lowest class of notes are often overcollateralized where the principal value of the notes issued are valued less than the principal value of the original underlying assets.

4. **A** The constant prepayment rate (CPR) and the Public Securities Association (PSA) method are common methodologies used to estimate prepayments for student loans and mortgages.

5. **D** The WAM is calculated as follows:

$$\text{WAC} = [90(2\text{ million}) + 180(3\text{ million}) + 270(5\text{ million}) + 360(10\text{ million})] / (2\text{ million} + 3\text{ million} + 5\text{ million} + 10\text{ million})$$

$$= (180\text{ million} + 540\text{ million} + 1{,}350\text{ million} + 3{,}600\text{ million}) / 20\text{ million}$$

$$= 5{,}670\text{ million} / 20\text{ million}$$

$$= 284\text{ days}$$

The following is a review of the Credit Risk Measurement and Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Understanding the Securitization of Subprime Mortgage Credit

Topic 36

Exam Focus

This topic describes many important aspects of the subprime markets. Seven frictions between market participants are discussed involving mortgagors, originators, arrangers, rating agencies, asset managers, and investors. You should understand the information problem (moral hazard or adverse selection) for each friction. Characteristics of subprime mortgages are also discussed including loan terms, performance, and subordination. For the exam, be familiar with subprime mortgage securitization, the frictions in the subprime market, and the process of rating subprime securities.

The Subprime Securitization Process

LO 36.1: Explain the subprime mortgage credit securitization process in the United States.

The subprime securitization process in the United States involves several different parties beginning with the borrowing needs of the home buyer. The borrower (mortgagor) applies for a mortgage and, conditional on the due diligence of the lender, is extended a loan with the residence serving as collateral. Borrowers range in quality from prime (i.e., strong credit history) to Alt-A (i.e., borrowers with good credit but more aggressive underwriting standards) to subprime (i.e., borrowers with poor credit history). Lenders sell a significant portion of their loans to a third-party (special purpose vehicle) and receive cash in return. Prime loans that meet conforming standards are sold to government sponsored enterprises (GSEs). The remaining loans are increasingly being sold and taken off the originators' balance sheet. Approximately 75% of newly originated subprime mortgages were securitized in 2005 and 2006.

Frictions in Subprime Mortgage Securitization

LO 36.2: Identify and describe key frictions in subprime mortgage securitization, and assess the relative contribution of each factor to the subprime mortgage problems.

In general, when two parties do not have the same information (which is usually the case), a sub-optimal outcome results. The two broad classes of information problems we will discuss here are moral hazard and adverse selection. **Moral hazard** denotes the actions one party may take to the detriment of the other. A classic example is the shareholder-manager relationship where the managers may use their position for personal gain rather than for

the shareholders to whom they owe a fiduciary duty. On the other hand, **adverse selection** is when one party possesses important hidden information. For example, a person's driving ability is private knowledge and a potential buyer of auto insurance will have the incentive to represent themselves as good drivers even if they are not. Mechanisms are designed to minimize these information problems such as board oversight for the managers and examination of driving records for those seeking auto insurance.

There are seven frictions in the mortgage securitization process. Each friction is discussed as follows.

Friction 1: *Mortgagor and originator*. The typical subprime borrower is typically financially unsophisticated. As a result, the borrower may not select the best borrowing alternative for themselves. In fact, the borrower may not even be aware of the financing options available. On the other hand, the lender may steer the borrower to products that are not suitable.

Friction 2: *Originator and arranger*. The arranger (issuer) purchases the loans from the originators for the purpose of resale through securitized products. The arranger will perform due diligence but still operates at an information disadvantage to the originator. That is, the originator has superior knowledge about the borrower (adverse selection problem). In addition, the originator may falsify or stretch the bounds of the application resulting in larger than optimal lending (predatory lending or predatory borrowing as discussed in LO 36.8).

Friction 3: *Arranger and third-parties*. The arranger of the pool of mortgages will possess better information about the borrower than third parties including rating agencies, asset managers, and warehouse lenders. The adverse selection problem gives the arranger the opportunity to retain the higher quality mortgages and securitize the lower quality mortgages (i.e., lemons).

The warehouse lender temporarily holds and finances the underlying purchases. As a precaution, the warehouse will fund less than 100% of its estimated collateral value forcing the arranger to retain a equity position on its balance sheet.

The asset portfolio manager purchases the assets for the pool from the arranger. Once again, the arranger has superior information about the creditworthiness of the mortgage pool. To minimize the potential adverse selection problem, the asset manager must use adequate due diligence, use reputable arrangers, and force credit enhancements from the arranger.

Similarly, the rating agencies determine the amount of credit enhancement necessary to achieve the desired credit rating. Thus, the rating agency is dependent on the information provided by the arranger. Typically, the due diligence on the arranger and originator is rushed.

Friction 4: *Servicer and mortgagor*. The servicer's role is to manage the cash flows of the pool and follow up on delinquencies and foreclosures. A conflict of interest arises for delinquent loans. The homeowner in financial difficulty does not have the incentive to upkeep tax payments, insurance, or maintenance on the

property. Escrowed funds can minimize this problem but ultimately efficient foreclosure must comply with federal regulations.

Friction 5: *Servicer and third-parties*. The servicer faces a moral hazard problem because their (lack of) effort can impact the asset manager and credit rating agencies without directly affecting their own cash flow distribution. In delinquency, the servicer is responsible for the property taxes and insurance premiums. These funds are reimbursable upon foreclosure so there is a temptation to exaggerate the fees and expenses particularly with high recovery rates.

The servicer also has an incentive to keep the problem loan on its books by modifying loan terms rather than foreclose (investor preference). Since most of the costs are unrecoverable (escrow analysis, payment set up, etc.) the property needs to be active to generate any additional funds to the servicer.

It is apparent that the quality of the servicer can directly impact the cash flows of the pool which in turn affects the credit rating. Changes in credit ratings reflect poorly on the agency. Therefore, the credit rating agencies must use due diligence in analyzing the servicer as well as the underlying collateral.

Friction 6: *Asset manager and investor*. The investor relies on the asset manager's expertise to identify and analyze potential investments. It is difficult for the investor to comprehend the investment strategy and the investor will not be able to observe the effort of the management team (same moral hazard problem as shareholder-manager). Investment mandates and proper benchmarking can mitigate some of the distortion.

Friction 7: *Investor and credit rating agencies*. Rating agencies are compensated by the arranger and not the end user, the investor. To the extent that the rating agencies are beholden to the fee structure of the arranger, a conflict of interest arises. In addition, it is very difficult to judge the accuracy of their models particularly with complex products and rapid financial innovation.

Five of these factors are direct contributors to the recent subprime crisis. First, the complexity of the product and naïve nature of the borrower led to inappropriate loans (friction 1). Second, managers sought the additional yield from structured mortgage products without fully assessing the associated risks (friction 6). Third, the problem became more expansive as underperforming managers made similar investments with less due diligence on the arranger and originator (friction 3). Fourth, as the asset managers reduced their oversight, it was natural that the arranger would follow suit (friction 2). This left the credit rating agencies as the last line of defense but they operated at a significant informational disadvantage. Finally, the assigned ratings were hopelessly misguided (friction 7).

Characteristics of the Subprime Mortgage Market

LO 36.3: Describe the characteristics of the subprime mortgage market, including the creditworthiness of the typical borrower and the features and performance of a subprime loan.

Subprime borrowers have a history of either default or strong indicators of possible future default. Past incidents include 30- or 60-day delinquencies, judgments, foreclosures, repossessions, charge-offs, or bankruptcy filings. Low FICO scores (660 or below) or a high debt service ratio of 50% or more are likely indicators of future default.

The vast majority of subprime loans are adjustable rate mortgages. The loan offers a teaser rate for a short period of time, and then adjusts each year relative to a floating rate index (usually LIBOR). The 2- and 3-year teaser rates are called 2/28 and 3/27 hybrid arms denoting the fixed and floating terms, respectively (e.g., fixed term is 2 years, floating term is 28 years). Since the majority of the term of the mortgage is floating, the borrower is bearing the interest rate risk in contrast to a traditional fixed rate mortgage where the lender bears the interest rate risk.

The performance of subprime pools indicates defaults and foreclosures way above historical levels. As a point of reference, the authors of the assigned reading analyze a New Century pool originating in May 2006 and estimate a 23% cumulative default rate through August 2007.

Securitized pools incorporate structures to provide protection to investors from losses in the collateral including subordination, excess spread, shifting interest, performance triggers, and interest rate swaps.

Subordination involves creating tranches of differing priority levels. Losses are applied first to the most subordinated tranche, the equity tranche. The equity tranche is usually created from overcollateralization (i.e., assets in excess of face value). If the losses exceed the size of this tranche then losses will reach the next highest subordinated level called the mezzanine. Credit ratings on mezzanine debt typically vary from AA to B. In this fashion, the most senior tranche is protected by all the junior tranches and offers the lowest return.

Mortgages pools are typically constructed so that the weighted average coupon (less servicing, hedging, and other expenses) exceeds the weighted average payout. The difference is called the **excess spread** which is paid to equity tranche investors when available. Thus, the excess spread protects all tranches.

Under **shifting interest**, the senior investors receive all principal in the pool while the mezzanine investors receive only interest. The senior holders may receive the principal for a set period of time ("lockout period") or until a cutoff ratio is reached.

Performance triggers denote the release of overcollateralizion which is applied from the bottom of the capital structure up.

Since the first few years of the pool are fixed, the pool faces interest rate risk. As protection, **interest rate swaps** are used where the pool will pay a fixed rate and receive a floating rate.

The Credit Ratings Process

LO 36.4: Describe the credit ratings process with respect to subprime mortgage backed securities.

A credit rating is defined as an opinion on the creditworthiness of the specific bond issue. Note that the assigned rating is specific to the security and in no way a reflection on the originator. The ratings represent an unconditional view of the rating agency as they rate "**through-the-cycle.**"

The rating process involves two steps: (1) estimation of loss distribution and (2) simulation of the cash flows. Once the estimates are obtained, the agency indicates the level of credit enhancement necessary to achieve the desired rating. If the projected rating is too low, the originator can provide additional enhancement to raise the rating.

LO 36.5: Explain the implications of credit ratings on the emergence of subprime related mortgage backed securities.

Assigning credit ratings for securitized assets presents additional challenges. Credit ratings for subprime securities, and more generally asset-backed securities (ABS), differ from corporate ratings in several important ways. First, corporate bond ratings are based on the firm-specific characteristics of the issuer where as ABS is a claim on a portfolio. Hence, systematic risk and degree of correlation between assets is important in the latter but not the former. ABS represents claims on a static pool and cannot infuse additional capital or restructure as a corporation can. In addition, the forecasts for ABS incorporate future economic conditions since the cash flow stream is tied to the macro environment. Finally, while corporates and ABSs with the same rating may indicate similar default probabilities, the ABS will exhibit much wider variation in losses.

LO 36.6: Describe the relationship between the credit ratings cycle and the housing cycle.

The goal of the rating system is to rate through-the-cycle, meaning that there should not be excessive upgrades (downgrades) if the housing market heats up (slows down). A problem may arise if the agency assigns, say, an AAA rating during a boom period. As the housing market slows down, the probability of default increases and the security has migrated to AA even though the agency has not made a public pronouncement. The problem is further exacerbated if new deals are based on the credit enhancements from the AAA rating in the boom period.

As economic conditions change, it is expected to see some upgrades or downgrades in mortgage-backed securities. However, the effect may amplify up and down markets. For example, in a downward trending market, additional enhancements are needed to maintain the highest ratings. This "crowds out" the credit available for lower rated borrowers increasing the required loan rate or raising qualification standards. The opposite is true for housing upturns freeing up credit for lower rated borrowers.

Cash Flow Analysis of Excess Spread

In the ratings process it is necessary to simulate the cash flows of the structure to forecast the degree of excess spread used for credit enhancement. As you can imagine, the forecasts are complex and depend on several interrelated factors including credit enhancement, timing of losses, prepayment rates, interest rates, trigger events, weighted average loan rate decrease, prepayment penalties, pre-funding accounts, and hedging instruments. The more important factors are discussed as follows.

First, the credit enhancement identifies the amount of collateral that can be impaired before the tranche suffers an economic loss. The timing of losses is also important because as losses accumulate, less excess spread will be available. A more conservative approach would front-load the losses. Prepayments will directly impact the excess spread. Prepayments may be voluntary (refinance, sales) or involuntary (default) so the prepayment assumption directly impacts the cash flow analysis. Prepayments typically follow the CPR (conditional prepayment rate) convention. However, it is important to note that hybrids will have higher than predicted defaults on or about the reset date due to the sudden change in rates and financial condition of the subprime borrower. A more conservative view would accelerate prepayments reducing further interest collections. Finally, the path of interest rates introduces uncertainty into the projected cash flow stream. Interest rates determine the adjustments (i.e., cash inflows), and influence refinancing.

LO 36.7: Explain the implications of the subprime mortgage meltdown on portfolio management.

Currently, the rating agencies collectively monitor approximately 10,000 mortgage pools. It would be impractical to monitor each pool on a monthly basis in detail. It is current practice to annually review each individual pool. An important performance measure used during this review is the **loss coverage ratio** (LCR), defined as: (current credit enhancement for tranche) / (estimated unrealized losses). An example of a credit enhancement is excess spread. If the LCR is breached (i.e., falls below what is acceptable), a full review is warranted.

Predatory Lending and Borrowing

LO 36.8: Compare predatory lending and borrowing.

Predatory lending results in the borrower becoming worse off after the loan than before. This may happen because the rates are deceptively high, the appraisals are inflated allowing the borrower to extract equity and then cannot refinance, and prepayment penalties are extreme, steering borrowers unnecessarily to subprime products and similar ruses. Predatory lending may also include outright fraudulent activity in addition to deception.

Predatory borrowing is misrepresentation in the mortgage application from the borrower side. The temptation is driven by increasing housing prices whereby the borrower feels that he cannot catch up with housing prices. Therefore, lying on the mortgage application allows the borrower to the buy the house with the expectation that continued appreciation will allow a favorable refinancing. The fraud may be perpetrated by the buyer alone or in concert with lawyers, broker, and appraisers.

Key Concepts

LO 36.1

The recent past has witnessed about 75% of subprime mortgages securitized.

LO 36.2

Frictions involve the borrower, originator, arranger, asset manager, investor, and rating agency. The frictions are based on adverse selection and moral hazard problems.

Ultimately, the lack of due diligence on the asset manager and arranger led to even looser underwriting standards. The credit rating agencies issued ratings that lacked this key information.

LO 36.3

Subprime mortgages are mainly hybrid arms (2/28 and 3/27) where the term denotes fixed and floating, respectively. Hence, the borrower retains the vast majority of the interest rate risk.

The capital structure of a pool places the safest securities on top (senior notes), junior securities in the middle (mezzanine) and riskiest on the bottom (equity).

Subordination, excess spread, and shifting interest provide protection for the senior tranches.

LO 36.4

Credit ratings are determined by the amount of collateralization in the structure. If the projected cash flows are insufficient to warrant a desired rating, the originator can supply additional enhancement.

LO 36.5

Credit ratings for ABSs are more complex than corporate ratings because of the underlying portfolio nature and correlation between assets, dependence on economic forecasts, and static nature of the collateral pool.

LO 36.6

Credit ratings are designed to rate through-the-cycle so that there are not excessive upgrades (downgrades) during housing booms (busts). However, changing required enhancements amplify the impact on housing markets by reducing credit in down markets and increasing credit in up markets for the lowest rated borrowers.

LO 36.7

Rating agencies collectively monitor approximately 10,000 mortgage pools. It's impractical to monitor each pool on a monthly basis in detail, so annual reviews are preferred.

LO 36.8

Predatory lending is when the borrower's welfare is reduced after undertaking the loan. The key characteristic is that the borrower has entered into an agreement with unfavorable terms. Predatory borrowing is when the borrower knowingly misrepresents his financial condition to secure a loan that he otherwise would not qualify for.

Concept Checkers

1. Which of the following is not a friction in the subprime securitization market?
   A. Investor and rating agency.
   B. Servicer and mortgagor.
   C. Mortgagor and arranger.
   D. Asset manager and investor.

2. Which of the following frictions represents an adverse selection problem?
   A. Investor and mortgagor.
   B. Originator and arranger.
   C. Servicer and rating agency.
   D. Servicer and mortgagor.

3. Which of the following statements about subprime mortgages is true? Subprime mortgages:
   A. are typically fixed rate obligations.
   B. often use the 2/28 or 3/27 hybrid structure.
   C. force the lender to bear most of the interest rate risk.
   D. are simpler to analyze than corporate bonds.

4. Which of the following is true about predatory lending and predatory borrowing?
   A. Both underprovide credit.
   B. Both overprovide credit.
   C. Predatory lending underprovides credit and predatory borrowing overprovides credit.
   D. Predatory lending overprovides credit and predatory borrowing underprovides credit.

5. Which of the following subprime characteristics provide direct protection for senior tranches?
   A. Subordination, excess spread, and shifting interest.
   B. Subordination, prepayments, and shifting interest.
   C. Overcollateralization, excess spread, and timing of losses.
   D. Overcollateralization, excess spread, and prepayments.

Concept Checker Answers

1. **C** The mortgagor and arranger have no direct contact so there is no friction.

2. **B** The originator has better information about the quality of the borrowers so the arranger is subject to an adverse selection problem. That is, if the originator keeps the high quality mortgages, the arranger will receive lemons.

3. **B** Most subprimes are 2/28 or 3/27 structures where the fixed component is for two or three years. Hence, the remainder of the term (27 or 28 years) is variable and bears the majority of the interest rate risk.

4. **B** Predatory borrowing is when the borrower misrepresents themselves to obtain credit they otherwise would be denied. Predatory lending is providing credit that is welfare decreasing and should not be provided.

5. **A** Subordination, excess spread, and shifting interest provide protection for senior tranches. Overcollateralization also provides protection for senior tranches. Timing of losses impacts excess spreads. Prepayments can accelerate or decelerate the cash flows to senior tranches.

Self-Test: Credit Risk Measurement and Management

10 Questions: 30 Minutes

1. A firm is experiencing financial difficulties. Using a contingent claims approach, which of the following best describes the valuation of their senior and subordinated debt?
   A. Both the senior debt and subordinated debt have positive exposures to debt maturity, firm volatility, and interest rates (i.e., the debt value increases as these factors increase).
   B. The senior debt has negative exposures to debt maturity, firm volatility, and interest rates (i.e., the senior debt value decreases as these factors increase). The subordinated debt has positive exposures to debt maturity, firm volatility, and interest rates (i.e., the subordinated debt value increases as these factors increase).
   C. The senior debt has positive exposures to debt maturity, firm volatility, and interest rates (i.e., the senior debt value increases as these factors increase). The subordinated debt has negative exposures to debt maturity, firm volatility, and interest rates (i.e., the subordinated debt value decreases as these factors increase).
   D. Both the senior debt and subordinated debt have negative exposures to debt maturity, firm volatility, and interest rates (i.e., the debt value decreases as these factors increase).

2. Suppose a portfolio has a value of $1,000,000 with 50 independent credit positions. Each of the credits has a default probability of 2% and a recovery rate of 0%. The credit portfolio has a default correlation equal to 0. The number of defaults is binomially distributed and the 95th percentile of the number of defaults is 3. What is the credit value at risk at the 95% confidence level for this credit portfolio?
   A. $20,000.
   B. $40,000.
   C. $60,000.
   D. $980,000.

3. Continuously increasing default probability (while holding default correlation constant) will most likely have what effect on the credit VaR of mezzanine and equity tranches?

	Equity VaR	Mezzanine VaR
A.	Increase	Increase then decrease
B.	Increase	Decrease then increase
C.	Decrease	Increase then decrease
D.	Decrease	Decrease then increase

4. Which of the following statements regarding counterparty risk and lending risk is correct?
   A. For an interest-rate swap, counterparty risk exists because default may occur at the end of the contract term.
   B. With counterparty risk, there is uncertainty as to which counterparty will have a negative mark-to-market value.
   C. Lending risk involves bilateral risks.
   D. With lending risk, the principal amount at risk is known with absolute certainty at the outset.

5. Netting refers to the combining of cash flows from different contracts with a counterparty into a single net amount. This method of mitigating counterparty risk has enabled explosive growth in credit exposures. Which of the following statements is incorrect regarding the advantages and disadvantages of netting?
   A. Netted exposures can be volatile, which may result in difficulty in controlling exposure.
   B. Netting removes risks by executing a reverse position with a counterparty, removing both default and operational risk, but not market risk.
   C. Without netting, entities trading with insolvent or troubled counterparties would be motivated to cease trading and terminate existing contracts.
   D. By offsetting exposures with parties managing net positions only, netting reduces risk and improves operational efficiency.

6. Counterparty Y is attempting to transfer posted collateral to another counterparty as collateral through a process of rehypothecation. Assuming that Counterparty X pledges collateral to Counterparty Y, and then Counterparty Y rehypothecates this collateral to Counterparty Z, what will happen if Counterparty Z defaults?
   A. Counterparty X will receive its original collateral back from Counterparty Z.
   B. Counterparty Y will have a liability to Counterparty X for not returning its collateral.
   C. Counterparty Y will profit from not receiving the collateral from Counterparty Z given that a credit event has occurred.
   D. Counterparty Y will accept a haircut on the value of the pledged collateral in order to reclaim a portion of the collateral.

7. Teresa Harrison, a junior portfolio manager, is considering the purchase of super senior tranches for her client portfolios. The typical client is fairly conservative and concerned more with downside risk than upside potential. Harrison based her recommendation on the following observations:
   - Senior tranches have large attachment points and hence a low probability of credit losses.
   - Mezzanine tranches represent the first loss piece of the capital structure.
   - Synthetic CDOs have standardized tranche widths similar to index tranches.

   How many of these observations support Harrison's view of tranches?
   A. 0.
   B. 1.
   C. 2.
   D. 3.

8. A portfolio consists of two bonds, Bonds A and B. The credit VaR for the portfolio is defined as the maximum loss due to defaults at a confidence level of 98% over a one-year horizon. The probability of joint default of the two bonds is 1.32%, and the default correlation is 35%. The bond value, default probability, and recovery rate are USD 1.2 million, 4%, and 60%, respectively for Bond A, and USD $800,000, 5%, and 35%, respectively for Bond B. What is the expected credit loss for the portfolio?
A. $45,200.
B. $15,820.
C. $42,800.
D. $26,400.

9. High Flying Hedge Fund will enter into a $100 million total return swap on the S&P 500 Index as the index receiver (i.e., total return receiver). The counterparty (i.e., total return payer) will receive 1-year LIBOR + 400bp. The contract will last two years and will exchange cash flows annually.
- Current LIBOR = 3%.
- Current S&P 500 value = 2,000.
- S&P 500 in one year = 2,200.
- S&P 500 in two years = 1,760.

Given this information, what are the cash flows to High Flying in one year and in two years, respectively? Assume LIBOR remains flat.

	1 Year	2 Years
A.	+3 million	–13 million
B.	+3 million	–27 million
C.	+13 million	–13 million
D.	+13 million	–27 million

10. Five tranches of auto loan asset-backed securities (ABSs) are issued with a face value of $6,000,000 and pay an average coupon of 5.2%. The value of the auto loans is $6,800,000, and they have an average interest rate of 5.4%. The fee for servicing the ABS is 0.2%. Which of the following credit enhancements are involved with this transaction?
A. Excess spread.
B. Margin step-up.
C. Subordinating note classes.
D. Overcollateralization.

Self-Test Answers: Credit Risk Measurement and Management

1. **B** If a firm is in financial distress, the subordinated debt behaves more like equity and a call option. It will increase in value as time to maturity increases, volatility increases, and interest rates increase. The senior debt will have negative exposures to these factors.

   If the firm is not in distress, both the senior debt and subordinated debt have negative exposures to these factors because the subordinated debt behaves more like senior debt than equity. In this case, choice D would be correct.

   (See Topic 20)

2. **B** The loss given default is \$60,000 [3 × (\$1,000,000 / 50)]. The expected loss is equal to the portfolio value times π and is \$20,000 (0.02 × \$1,000,000). The credit VaR is defined as the quantile of the credit loss less the expected loss of the portfolio. At the 95% confidence level, the credit VaR is equal to \$40,000 (\$60,000 minus the expected loss of \$20,000).

   (See Topic 22)

3. **C** Increasing the probability of default decreases equity VaR as defaults are more likely, and the equity tranche will suffer writedowns. However, the writedowns are bounded by the thin level of subordination so the variation in losses becomes smaller. Mezzanine tranches behave more like senior bonds at low default levels (increasing VaR) but more like the equity tranche at higher default levels (decreasing VaR).

   (See Topic 23)

4. **B** With counterparty risk, there is uncertainty regarding which counterparty will have a negative MtM value. For an interest-rate swap, there is no counterparty risk at the end of the contract term because all payments required by the contract would have been made by then. With lending risk, only one party (unilateral) takes on risk. In addition, the principal amount at risk is known only with reasonable certainty at the outset because changes in interest rates, for example, will lead to some uncertainty.

   (See Topic 24)

5. **B** If an entity wishes to exit a less liquid OTC trade with one counterparty by entering into an offsetting position with another counterparty, the entity will remove market risk; however, it will be exposed to counterparty and operational risk. Netting removes these risks through executing a reverse position with the initial counterparty, removing both market and counterparty risk.

   (See Topic 25)

6. **B** In rehypothecation, party X may pledge collateral to party Y and party Y may rehypothecate this collateral to party Z. If party Z defaults, then party Y will not only have a loss from not receiving the collateral from party Z, it will also have a liability to party X for not returning its collateral.

(See Topic 26)

7. **B** Only recommendation 1 is correct. Senior tranches have a low probability of default because their attachment points are much higher in the capital structure. Equity tranches represent the first loss position. Index tranches, not synthetic CDOs, have standardized tranche widths.

(See Topic 29)

8. **A** The joint expected credit loss is the sum of the two individual expected credit losses.

$EL = PD \times \text{exposure} \times LGD$

$EL_{\text{Bond A}} = \$1{,}200{,}000 \times 0.04 \times 0.40 = \$19{,}200$

$EL_{\text{Bond B}} = \$800{,}000 \times 0.05 \times 0.65 = \$26{,}000$

$\text{Total EL} = \$45{,}200$

Note that expected credit loss does not depend on the correlation between the bonds.

(See Topic 32)

9. **B** Over the next year, the S&P 500 Index will increase by 10%. Hence, the index receiver (High Flying) will receive $10 million from the index payer and will pay $7 million (LIBOR = 3% + 400bp) to the counterparty. Therefore, the net cash flow will be +$3 million to High Flying.

Between years 1 and 2, the S&P 500 Index will drop 20%. Now, High Flying as the total return receiver must *pay* 20% to the counterparty in addition to the 7% floating rate. Hence, the total outflow from High Flying to the counterparty is $27 million.

(See Topic 34)

10. **D** This ABS is supported by overcollateralization because the value of the asset pool is greater than the value of the securities. There is no excess spread involved because there is no difference between the cash inflows from the underlying assets and the cash outflows in the form of interest payments on the ABS issues.

(See Topic 35)

Formulas

Topic 16

expected loss: PD × LGD × EAD

Topic 18

exposure at default: EAD = drawn amount + (limit – drawn amount) × loan equivalency factor

marginal risk contribution: $\beta_i = \dfrac{ULC_i / w_i}{UL_{portfolio}}$

economic value added: EVA = (RARORAC – K_e) × economic capital

risk-adjusted return on risk-adjusted capital:

$$\text{RARORAC} = \frac{\text{spread} + \text{fees} - \text{EL} - \text{cost of capital} - \text{cost of operations}}{\text{economic capital}}$$

Topic 19

probability of default: $PD_k = \dfrac{\text{defaulted}_t^{t+k}}{\text{names}_t}$

where:
PD = probability of default
defaulted = number of issuer names that have defaulted in the applicable time horizon
names = number of issuers
k = time horizon

cumulative probability of default: $PD_k^{cumulative} = \dfrac{\sum_{i=t}^{i=t+k} \text{defaulted}_i}{\text{names}_t}$

marginal probability of default: $PD_k^{marginal} = PD_{t+k}^{cumulative} - PD_t^{cumulative}$

annualized default rate: discrete: $ADR_t = 1 - \sqrt[t]{\left(1 - PD_t^{cumulative}\right)}$

continuous: $ADR_t = -\dfrac{\ln\left(1 - PD_t^{cumulative}\right)}{t}$

Merton model PD: $PD = N\left(\dfrac{\ln(F) - \ln(V_A) - \mu T + \frac{1}{2}\sigma_A^2 T}{\sigma_A \sqrt{T}}\right)$

where:
ln = the natural logarithm
F = debt face value
V_A = firm asset value (market value of equity and net debt)
μ = expected return in the "risky world"
T = time to maturity remaining
σ_A = volatility (standard deviation of asset values)
N = cumulated normal distribution operator

distance to default: $DtD = \dfrac{\ln(V_A) - \ln(F) + \left(\mu_{risky} - \dfrac{\sigma_A^2}{2}\right) - \text{"other payouts"}}{\sigma_A} \cong \dfrac{\ln V - \ln F}{\sigma_A}$

Altman's Z-score: $Z = 1.21x_1 + 1.40x_2 + 3.30x_3 + 0.6x_4 + 0.999x_5$

where:
x_1 = working capital / total assets
x_2 = accrued capital reserves / total assets
x_3 = EBIT / total assets
x_4 = equity market value / face value of term debt
x_5 = sales / total assets

LOGIT model: $\text{LOGIT}(\pi_i) = \log \dfrac{\pi_i}{1 - \pi_i}$

Topic 20

credit spread $= -\left[\dfrac{1}{(T - t)}\right] \times \ln\left(\dfrac{D}{F}\right) - R_F$

where:
$(T - t)$ = remaining maturity
D = current value of debt
F = face value of debt
R_F = risk-free rate

vulnerable option = $[(1 - PD) \times c] + (PD \times RR \times c)$

where:
c = value of the option without default
PD = probability of default
RR = recovery rate

Topic 21

cumulative PD: $1 - e^{-\lambda t}$

default probability: $\lambda_T^* \approx \dfrac{z_T}{1 - RR}$

Topic 22

correlation with default probabilities: $\rho_{12} = \dfrac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$

Topic 27

$$\text{netting factor} = \frac{\sqrt{n + n(n-1)\bar{\rho}}}{n}$$

where:
n = number of exposures
$\bar{\rho}$ = average correlation

Topic 29

risk-neutral default probability = liquidity premium + default risk premium + real-world default probability

cumulative default probability: $F(u) = 1 - \exp\left[-\dfrac{\text{spread}}{1-\text{recovery}} \times u\right]$

$$\text{number of defaults} = n\left(\frac{X\%}{1-\text{recovery}}\right)$$

Topic 30

credit value adjustment: $\text{CVA} = \text{LGD} \times \sum_{i=1}^{m} \times \text{EE}(t_i) \times \text{PD}(t_{i-1}, t_i)$

where:
LGD = loss given default or how much of the exposure one expects to lose in the event of a counterparty default; equal to 1 minus the recovery rate (1 – RR)
EE = discount expected exposure for future dates
PD = marginal default probability

CVA as a spread: $\dfrac{\text{CVA}(t,T)}{\text{CDS}_{\text{premium}}(t,T)} = X^{\text{CDS}} \times \text{EPE}$

where:
$\text{CDS}_{\text{premium}}(t, T)$ = unit premium value of a credit default swap
X^{CDS} = CDS premium at maturity date *T*; this amount can be thought of as a credit spread
EPE = expected positive exposure that is the average of the expected exposure over a preset time period, typically from the present to the maturity date of the transaction

bilateral credit value adjustment: $BCVA = CVA + DVA$

$$CVA = +LGD_C \times \sum_{i=1}^{m} EE(t_i) \times PD_C(t_{i-1}, t_i)$$

$$DVA = -LGD_I \times \sum_{i=1}^{m} NEE(t_i) \times PD_I(t_{i-1}, t_i)$$

where:
NEE = negative expected exposure (EE from the counterparty's perspective)

BCVA as spread: $\dfrac{BCVA(t,T)}{CDS_{premium}(t,T)} = X_C^{CDS} \times EPE - X_I^{CDS} \times ENE$

where :
X_I^{CDS} = the institution's own CDS spread
ENE = expected negative exposure (the opposite of EPE)

Topic 32

loan portfolio expected loss: $EL = \sum_{i=1}^{N} PD_i \times EAD_i \times LGD_i$

deriatives portfolio expected loss: $EL = \sum_{i=1}^{N} PD_i \times (EPE_i \times \alpha) \times LGD_i$

Topic 35

weighted average life (WAL): $WAL = \sum (a / 365) \times PF(t)$

constant prepayment rate: $CPR = 1 - (1 - SMM)^{12}$

Using the Cumulative Z-Table

Probability Example

Assume that the annual earnings per share (EPS) for a large sample of firms is normally distributed with a mean of \$5.00 and a standard deviation of \$1.50. What is the approximate probability of an observed EPS value falling between \$3.00 and \$7.25?

If EPS = x = \$7.25, then $z = (x - \mu)/\sigma = (\$7.25 - \$5.00)/\$1.50 = +1.50$

If EPS = x = \$3.00, then $z = (x - \mu)/\sigma = (\$3.00 - \$5.00)/\$1.50 = -1.33$

For z-value of 1.50: Use the row headed 1.5 and the column headed 0 to find the value 0.9332. This represents the area under the curve to the left of the critical value 1.50.

For z-value of –1.33: Use the row headed 1.3 and the column headed 3 to find the value 0.9082. This represents the area under the curve to the left of the critical value +1.33. The area to the left of –1.33 is 1 – 0.9082 = 0.0918.

The area between these critical values is 0.9332 – 0.0918 = 0.8414, or 84.14%.

Hypothesis Testing – One-Tailed Test Example

A sample of a stock's returns on 36 non-consecutive days results in a mean return of 2.0%. Assume the population standard deviation is 20.0%. Can we say with 95% confidence that the mean return is greater than 0%?

H_0: $\mu \leq 0.0\%$, H_A: $\mu > 0.0\%$. The test statistic = *z*-statistic = $\dfrac{\bar{x} - \mu_0}{\sigma / \sqrt{n}}$
= (2.0 – 0.0) / (20.0 / 6) = 0.60.

The significance level = 1.0 – 0.95 = 0.05, or 5%.

Since this is a one-tailed test with an alpha of 0.05, we need to find the value 0.95 in the cumulative *z*-table. The closest value is 0.9505, with a corresponding critical *z*-value of 1.65. Since the test statistic is less than the critical value, we fail to reject H_0.

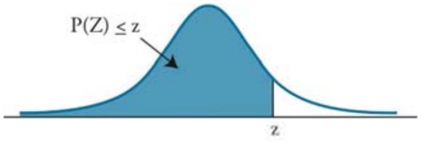
Hypothesis Testing – Two-Tailed Test Example

Using the same assumptions as before, suppose that the analyst now wants to determine if he can say with 99% confidence that the stock's return is not equal to 0.0%.

H_0: $\mu = 0.0\%$, H_A: $\mu \neq 0.0\%$. The test statistic (*z*-value) = (2.0 – 0.0) / (20.0 / 6) = 0.60.
The significance level = 1.0 – 0.99 = 0.01, or 1%.

Since this is a two-tailed test with an alpha of 0.01, there is a 0.005 rejection region in both tails. Thus, we need to find the value 0.995 (1.0 – 0.005) in the table. The closest value is 0.9951, which corresponds to a critical *z*-value of 2.58. Since the test statistic is less than the critical value, we fail to reject H_0 and conclude that the stock's return equals 0.0%.

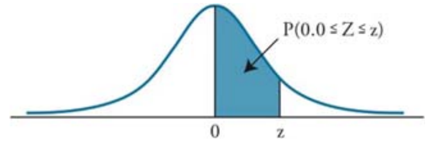
Cumulative Z-Table



$P(Z \leq z) = N(z)$ for $z \geq 0$
$P(Z \leq -z) = 1 - N(z)$

z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.937	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.983	0.9834	0.9838	0.9842	0.9846	0.985	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.989
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.994	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

Alternative Z-Table



$P(Z \leq z) = N(z)$ for $z \geq 0$

$P(Z \leq -z) = 1 - N(z)$

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3356	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4939	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

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